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Determination of Theoretical Relationships and Validation of Steam Load Forecasting Technique for Central Heating Plants

A Steam Load Forecasting Technique for Central Heating Plants

by
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Because boilers generally are most efficient at full loads, the Army could achieve significant savings by running fewer boilers at high loads rather than more boilers at low loads. A reliable load prediction technique could help ensure that only those boilers required to meet demand are on line.

This report presents the results of an investigation into the feasibility of forecasting heat plant steam loads from historical patterns and weather information. Using steam flow data collected at Fort Benjamin Harrison, IN, a Box-Jenkins transfer function model with an acceptably small prediction error was initially identified. The standard deviation of the 1-hour ahead prediction error using this formula was about 4 percent of the mean of the hourly steam flow forecast.

Initial investigation of forecast model development appeared successful, finding relatively accurate models that made 24-hour predictions. Dynamic regression methods using actual ambient temperatures yielded the best results. Box-Jenkins univariate models' results appeared slightly less accurate. Since temperature information was not needed for model building and forecasting, however, it is recommended that Box-Jenkins models be considered prime candidates for load forecasting due to their simpler mathematics. Weather information, nevertheless, should also be taken into account in case of a significant variation in ambient temperature within the applicable forecast period. The feasibility of completely automating the identification of the prediction formula should be studied for field implementation of multiboiler load allocation.

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FOREWORD

This study was conducted under Project 4A161102AT23, "Basic Research in Military Construction"; Work Unit EA-EC0, "Determination of Theoretical Relationships and Validation of Steam Load Forecasting Technique for Central Heating Plants."

This research was performed by the Energy and Utility Systems Division (ES), U.S. Army Construction Engineering Research Laboratory (USACERL). Mike C.J. Lin was the USACERL principal investigator. The Phase 1 study was done by Dr. James V. Camahan of the University of Illinois at Urbana-Champaign, Department of General Engineering. David M. Joncich is Chief, USACERL-ES. The USACERL technical editor was Gordon L. Cohen, Information Management Office.

COL Daniel Waldo Jr. is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

Boilers are generally designed to be highly efficient at full loads. As a boiler's load decreases, its efficiency also drops. The Army should achieve significant savings by running fewer boilers at high loads rather than more boilers at low loads. A reliable load prediction technique could help ensure that only those boilers required to meet demand are on line.

Boiler load is normally affected by weather changes. Since weather forecasting is still not a precise science, boiler operators tend to take a conservative approach and run as many boilers as they feel comfortable with. Operators could use a reliable load forecasting technique to schedule boiler operations with more efficiency, saving a significant amount of fuel. This could significantly improve the cost-efficiency of large central heating plants at many Army installations.

Time series analysis is a rapid-growth area in statistical science. Its major application is in forecasting. The Box-Jenkins approach, developed in the 1960s, was found to be well suited for load forecasting (Box and Jenkins, 1970). Load forecasting is now an integral part of utility system operation. Long-term forecasting several years into the future is required for scheduling new plant construction. Intermediate-term forecasts several months ahead are needed for scheduling maintenance. Short-term forecasting—a few days to a few weeks—is needed for scheduling generating capacity and fuel purchases. Forecasting a few hours to a few minutes ahead is required for real-time control. This research investigates a technique with relatively short-term (24 hour) forecasting for multiboiler load allocation in Army central heating plants.

Objective

The objective of this research is twofold: (1) to provide a fundamental understanding of the relationship between heating-degree days and steam load, and (2) to develop a mathematical model that results in reliable steam load forecasts based on historical trends and projected weather patterns. This information will form the basis of a steam supply load-leveling system for Army central heating plants.

Approach

An overview of forecasting techniques is provided. Applications reported in literature are summarized, and software considerations and data requirements are discussed. Chapters 6 through 9 present modeling results and conclusions based on steam flow data collected from Fort Benjamin Harrison, IN from February 1989 through September 1990.

This study was carried out in two phases. In Phase 1, a researcher at the University of Illinois at Urbana-Champaign (UIUC) investigated forecasting methods using statistical analysis software in a mainframe computing environment. In Phase 2, conducted at the U.S. Army Construction Engineering Research Laboratory (USACERL), the results of this work were adapted to user-friendly commercial software for use in a microcomputer environment.

Scope

The purpose of this work is to investigate the feasibility of forecasting heat plant steam load from past usage patterns and ambient temperature information. Only a limited amount of data from one central heating plant were used. Therefore, general applicability to other installations may require further study. The same methodology and procedure, however, can be used to build a working forecast model.

Mode of Technology Transfer

The results of this work should be incorporated into an Advanced Operations and Maintenance project for investigation of a boiler dispatching system and defining potential savings in a representative Army boiler plant.

2 METHODOLOGY

Overview

There are a number of different approaches to the building of mathematical models for use in forecasting. It is important to understand the forecasting problem and its particular requirements. Typically, forecasting models are judged on their accuracy in predicting the future, not on their fit to historical data. Nevertheless, the analyst uses the fit to historical data as a major evaluative component in assessing the accuracy of the model. In this report both the fit and the forecasting error will be discussed in evaluating the proposed models. Forecasting requires judgment as well as statistical analysis, especially in deciding whether the underlying assumptions made in developing the mathematics are valid.

Several mathematical approaches to forecasting exist, a few of which will be mentioned here. They include exponential smoothing, Box-Jenkins univariate and transfer function (multivariate) models, state space analysis, and dynamic regression. Exponential smoothing can often be improved upon by using a Box-Jenkins univariate model, if the data are sufficiently numerous. Box-Jenkins transfer function models are useful when the data to be predicted have correlational and seasonal structure, but there is additional influence of some exogenous* variables. For example, in the case under study here there are diurnal patterns in steam demand, but there is an additional significant influence due to temperature variation. However, when the situation calls for a Box-Jenkins transfer function model, it has been shown recently that a state space model is mathematically equivalent (Akaike, 1974a) and will sometimes be easier to construct (Granger and McCollister, 1978). There is another method which, in terms of complexity, is situated somewhat between Box-Jenkins univariate and state space models. This method has been given the name "dynamic regression" by some, and includes the Cochrane-Orcutt models popular with econometricians.

The statistical analysis software used in the Phase 1 study—*SAS***—has an econometric and time-series library (SAS/ETS) that permits a user to employ all of the methods mentioned above. Since *SAS* was the package most readily available for the Phase 1 study, it was employed even though it is somewhat awkward to use compared to statistical analysis software recently developed for microcomputers. Stellwagen and Goodrich, for example, have developed forecasting software for the Electric Power Research Institute (EPRI) that will easily undertake a variety of forecasting approaches, including all those mentioned above.

Box-Jenkins Univariate Models

A discussion of the univariate time series models of Box and Jenkins will be given here because it is the most straightforward and the concepts regarding correlational structures in data are common to the other approaches mentioned above.

Assume that a stochastic*** process can be observed at discrete instants of time so that there is a series z_t, $t=1,\ldots,N$, where the index t may indicate equally spaced instants of time. The mean and variance of the time series are the expected values

*Originating externally.

**Previously called the Statistical Analysis System, this software package is now known simply as SAS.

***Pertaining to random variables.

$$\mu_t = E[z_t] = \int_0^{\infty} p(z,t)dz \qquad \text{[Eq 1]}$$

$$\sigma_t^2 = E[(z_t-\mu_t)^2] = \int_0^{\infty} (z_t-\mu_t)^2\, p(z,t)dz \qquad \text{[Eq 2]}$$

where p(z,t) is the probability density function for z at time t. The estimates of these quantities are the usual ones

$$\bar{z} = (1/N) \sum_{t=1}^{N} z_t \qquad \text{[Eq 3]}$$

$$\hat{\sigma}^2 = (1/N) \sum_{t=1}^{N} (z_t-\bar{z})^2 \qquad \text{[Eq 4]}$$

If the process is weakly stationary, then μ_t and σ^2_t are constants, independent of the value of time, t, as is the autocovariance.

The autocovariance, γ_k, is defined as follows:

$$\gamma_k = E[(z_t-\mu_t)(z_{t+k}-\mu_{t+k})] \qquad \text{[Eq 5]}$$

The autocovariance is dependent only on the lag, k, between any two instants of time t and t+k, and not on the value of time, t. An estimate of the autocovariance is defined in a manner completely analogous to that given above for the variance, noting that $\sigma^2=\gamma_0$. Then the autocorrelation function at lag k, ρ_k, is defined as a normalized covariance

$$\rho_k = \gamma_k / \gamma_o \qquad \text{[Eq 6]}$$

making $0 \leq \rho_k \leq 1$ for all k.

The autocorrelation function for a stationary time series is an important identifying characteristic, and is used throughout the Box-Jenkins identification process. An important example of this is "white noise." If a time series a_t consists of identically normally distributed random variables that are independent of one another (and thus uncorrelated), the series is referred to as white noise. It has an autocorrelation function of 0 everywhere except when the lag is 0, in which case the autocorrelation function is 1. This concept is crucial, since one of the objectives of Box-Jenkins modeling is to construct a model for z_t so that the difference (residual) between the model and the observed values of z_t is statistically indistinguishable from white noise. There are statistical tests available to determine whether it is plausible to accept the hypothesis that a particular (residual) series is white noise; forecasting software packages routinely produce the results of such tests.

The mathematical structure of autoregressive and moving average models is examined in the following sections. It may seem unlikely that specific univariate model structures could possibly model

demand for power. Nevertheless, such models have proven successful in forecasting 5 minute, hourly, and daily loads, as indicated by Keyhani and El-Abiad (1975) and Hagan and Klein (1977). Numerous other references document successful applications, but only a few will be mentioned in this report.

To keep the mathematical statements compact, some operational notation will be introduced, although it is by no means standard. Since the literature on time series analysis and forecasting is so diverse and represents rival schools of thought, a uniform notation has not yet emerged.

The backshift operator b is defined such that

$$b\, z_t = z_{t-1}$$

and

$$b^m\, z_t = z_{t-m}$$

The differencing operator is defined such that

$$\begin{aligned} \nabla z_t &= z_t - z_{t-1} \\ &= (1-b) z_t \end{aligned} \qquad \text{[Eq 7]}$$

and

$$\begin{aligned} \nabla^2 z_t &= \nabla(z_t - z_{t-1}) \\ &= z_t - 2z_{t-1} + z_{t-2} \end{aligned} \qquad \text{[Eq 8]}$$

The random processes studied are assumed to be stationary. If there is evidence that they are not stationary, some transformation techniques can be applied to make them stationary, as will be discussed later. It will also be assumed that we study the process $\tilde{z}_t = z_t - \mu$, so that the mean of $\tilde{z}_t$ is zero. In order to simplify the notation that follows, we will use z_t instead of $\tilde{z}_t$ throughout, assuming its (constant) mean has already been removed. Of course, if the data are differenced once, the differenced series has a zero mean, and thus does not need to have the mean removed.

A first-order autoregressive process has the form

$$z_t = \phi_1 z_{t-1} + a_t \qquad \text{[Eq 9]}$$

where a_t is a white noise process. Intuitively, this suggests the next observation of the time series can be modeled by adding a random "shock" to the last observed value (multiplied by some constant, ϕ_1). This is the well known Markov process, which has found wide application throughout physics and mathematics (Akaike, 1974a). This expression can also be written in the form

$$(1-\phi_1 b)z_t = a_t \qquad \text{[Eq 10]}$$

leading to the following form for a process that is autoregressive of order p, often denoted as AR(p):

$$(1-\phi_1 b-\varphi_2 b^2-...-\phi_p b^p)z_t = a_t \qquad \text{[Eq 11]}$$

In a more abbreviated fashion, this can be expressed as

$$\phi(b)z_t = a_t \qquad \text{[Eq 12]}$$

where $\phi(b)$ is a polynomial of order p in terms of the backshift operator.

A famous application of AR(2) models was the prediction of the number of sunspots (Yule, 1927). The order p of a process supposed to be purely autoregressive can be determined by examination of its sample autocorrelation function, and especially by looking at a variation of it called the partial autocorrelation function. For instance, if the process is AR(1), the autocorrelation function has the simple form $\rho_k=\phi_1^k$. The coefficients ϕ_i, i=1,...,p are determined by maximum likelihood estimation. One may conveniently think of such an estimation scheme as one that chooses the ϕ_i that minimizes the variance of the residual series a_t, although this is not precisely the basis for maximum likelihood estimation.

A moving average process of order q, denoted as MA(q), has the form

$$\begin{aligned} z_t &= a_t-\theta_1 a_{t-1}-\theta_2 a_{t-2}-...-\theta_q a_{t-q} \\ &= (1-\theta_1 b-\theta_2 b^2-...-\theta_q b^q)a_t \\ &= \theta(b)a_t \end{aligned} \qquad \text{[Eq 13]}$$

where $\theta(b)$ is a polynomial of order q in the backshift operator. As with autoregressive processes, the order q for the moving average process can be determined by examining the autocorrelation function of the process, and the parameters θ_i, i=1,...,q are determined by a maximum likelihood estimation scheme.

A more general model is the autoregressive-moving average (ARMA) model for a time series, which takes the form

$$\phi(b)z_t = \theta(b)a_t \qquad \text{[Eq 14]}$$

if it is of order p and q, often denoted as ARMA(p,q). Models of this sort were investigated by Vemuri, Huang, and Nelson (1981) in order to estimate hourly loads for an electric utility.

If a time series z_t is not stationary, perhaps because it has a constant trend, it can be made stationary by a differencing operation

$$w_t = \nabla z_t \qquad \text{[Eq 15]}$$

resulting in w_t becoming a stationary series, ready to be modeled as an ARMA process. The differencing may be carried to a higher degree—perhaps d—if necessary to obtain a stationary process. In practice, the order of differencing is rarely more than 2, which is what is required to model some series with changing trends. Also, there are statistical measures that can be examined to determine whether the series has been over-differenced in an attempt to make it stationary.

After differencing has produced a stationary process, an autoregressive integrated moving average (ARIMA) model can be proposed:

$$\phi(b)\nabla^d z_t = \theta(b)a_t \qquad \text{[Eq 16]}$$

This is often referred to as an ARIMA (p,d,q) model when p and q are the orders of the $\phi(b)$ and $\theta(b)$ polynomials, respectively. Hagan and Klein (1977) used this sort of model to forecast hourly loads with up to a 4 hour lead time.

Another sort of nonstationary feature that stochastic processes can exhibit is heteroscedasticity, which means that σ^2_t is a function of t rather than a constant. Sometimes such a process can be rendered stationary by a power transformation of some sort, or perhaps by taking the logarithm of the series before beginning the modeling process. This did not appear to be required for the steam flow data studied here.

The last sort of seasonality that will be discussed here is a seasonal periodicity. This is best explained with an example. Suppose there is a series of hourly data that exhibits a diurnal pattern (daily periodicity). In oth. r words, the value of z_t is strongly related to the value of z_{t-24}. The time series would exhibit a cyclic behavior (though not necessarily sinusoidal) with a period of 24 hours. If the data had been collected at 5 minute intervals, then the period would be 288 with the value of z_t being strongly related to the value of z_{t-288}. Such periodic features are observed in portions of the steam flow data from Fort Benjamin Harrison, as can be seen from the graphs in Appendix A. Especially evident in the March "Steam 2" data are peaks and troughs in the data with a period of about 24 hours. These features are commonly observed in published load data at both 5 minute and hourly intervals, as provided, for example, by Abu-El-Magh and Sinha (1981). The seasonal difference operator is defined as

$$\nabla_{24} z_t = z_t - z_{t-24} \qquad \text{[Eq 17]}$$

For the hourly time series it might be proposed that

$$\nabla_{24} z_t = (1 - \Theta b^{24})\alpha_t \qquad \text{[Eq 18]}$$

in order to relate z_t that are 24 hours apart where

$$\nabla \alpha_t = (1 - \theta b) a_t \qquad \text{[Eq 19]}$$

might relate α that are 1 hour apart. Combining these equations gives a compact form of the model

$$\nabla \nabla_{24} z_t = (1 - \theta b)(1 - \Theta b^{24}) a_t \qquad \text{[Eq 20]}$$

Such a model is denoted a multiplicative (0,1,1) x $(0,1,1)_{24}$ model and requires the estimation of only two parameters: Θ and θ. Note the inclusion of certain moving average terms corresponding to the differencing operations. In order to make the notation clear, the model will be written out completely in a form that can be viewed as a difference equation:

$$z_t - z_{t-1} - z_{t-24} + z_{t-25} = a_t - \theta a_{t-1} - \Theta a_{t-24} + \theta \Theta a_{t-25} \qquad \text{[Eq 21]}$$

Then the forecast equation can be written directly and the result given for the case of forecasting k periods ahead. Clearly

$$\begin{aligned} z_{t+k} = {} & z_{t+k-1} + z_{t+k-24} - z_{t+k-25} + a_{t+k} \\ & - \theta a_{t+k-1} - \Theta a_{t+k-24} + \theta \Theta a_{t+k-25} \end{aligned} \qquad \text{[Eq 22]}$$

The forecasted value for z_{t+k} with the minimum mean square error will be the conditional expected value of z_{t+k}, given Θ, θ, z_t, z_{t-1}, ..., the estimated parameter values, and the time series up to and including the time point t.

This forecast will be denoted as $\hat{z}_t(k)$, and is given by

$$\begin{aligned} \hat{z}_t(k) = {} & E[z_{t+k-1} + z_{t+k-24} - z_{t+k-25} + a_{t+k} \\ & - \theta a_{t+k-1} - \Theta a_{t+k-24} + \theta \Theta a_{t+k-25} \mid \theta, \Theta, z_t, z_{t-1}, ...] \end{aligned} \qquad \text{[Eq 23]}$$

indicating that the forecast is k steps ahead, given the series is observed through time t. In order to obtain forecasts, the unknown z_j terms ($j > t$) are replaced by their forecasted values and the unknown a_i terms ($i > t$) are replaced by their mean value, which is 0 for a properly constructed model. On the other hand, the known values of a_i are the one-step-ahead forecast errors, that is

$$a_i = z_i - \hat{z}_{i-1}(1) \qquad \text{[Eq 24]}$$

for values of $i \leq t$, and $a_i = 0$ for $i > t$.

There are a variety of approaches for deciding which Box-Jenkins model should be used to describe a given time series. As previously mentioned, after model identification and parameter estimation, the residual series a_t should be statistically acceptable as white noise. Sometimes a practitioner will want to set aside some data, not to be used in fitting the model, and then use this data to evaluate the prediction error. *SAS*, the software package used in this phase of the research, readily permits this to be done for univariate models, but not for the multivariate models to be discussed later.

Also to be considered is the principle of parsimony, which dictates that simpler models are preferable. This is because a model that is too complex—often called "overfitted"—will describe many unimportant details of the historical data (including noise), making it unlikely to be very useful for forecasting. The Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) are two objective measures that balance goodness of fit and model complexity. In the forecasting work described here, the chi-square test for the residual series being white noise and the AIC were used as measures of acceptable fit of the model to historical data.

Box-Jenkins Transfer Function Models

The ARIMA models mentioned above, including the seasonal versions, are essentially complex extrapolations of past load history. When there is a change in the weather, a transfer function model can include a variable like temperature to improve the prediction. Consider a transfer function model such as

$$z_t = [\omega(b)/\delta(b)]x_{t-c} + n_t \qquad \text{[Eq 25]}$$

where $\omega(b)$ is a polynomial of order s, $\delta(b)$ is a polynomial of order r, and the input series x_t is lagged by c periods. It is assumed that the noise process n_t is not white but can be represented by an ARIMA model. By differencing the series hourly and daily (24 hours) to make it stationary, the general form of the transfer function model becomes

$$\nabla\nabla_{24} z_t = [\omega(b)/\delta(b)]\nabla\nabla_{24} x_{t-c} + [\theta(b)\Theta(b^{24})/\phi(b)\Phi(b^{24})]a_t \qquad \text{[Eq 26]}$$

where the orders and coefficients of the various polynomials are determined as a part of the identification process. As will be discussed later, the transfer function model identified from the data on steam flow and temperature had a relatively simple form, with $\delta(b)=1$, $\omega(b)=\omega_0$ (a constant), and relatively low order autoregressive and moving-average polynomials.

Other Modeling Approaches

Dynamic Regression

Dynamic regression refers to a group of regression models that combines the dynamics of Box-Jenkins models with the explanatory power of certain variables that may even be causal in nature. The

typical configuration is to exclude moving-average terms but to include a vector of exogenous variables (other than z_t) that might help explain variation in z_t. An example of such a formulation might be

$$\phi(b)z_t = \beta y_t + \omega_t \qquad \text{[Eq 27]}$$

$$R(b)\omega_t = a_t \qquad \text{[Eq 28]}$$

where z_t is the time series to be forecast, y_t is a vector of exogenous variables related to z_t, ß is a vector of regression coefficients, ω_t are raw residuals that are autocorrelated, and R(b) is the backwards shift polynomial that reduces ω_t to a white noise series a_t. This particular dynamic regression formulation is the Cochrane-Orcutt model (Cochrane and Orcutt, 1949). It would appear to have some promise for the steam load forecasting problem, but the model fitting using *SAS* was somewhat awkward. It seems advisable to wait until better forecasting software is available before investing much effort in investigating the usefulness of this class of models.

State Space Models

Another approach that includes some exogenous variables to improve forecasts is state space modeling, as proposed by Akaike (1974b). These models are statistically equivalent to Box-Jenkins ARMA transfer function models (as opposed to the univariate models discussed earlier in this chapter) and yield exactly the same forecasts. However, state space models can be much easier to identify and estimate when the transfer function model is complex. It turns out that a very simple transfer function was found, as indicated above, so the state space models were not pursued.

The mathematics of this representation are similar to those of modern control theory. Although they are not extremely involved, they will not be given in any detail here. If state space models are shown to be superior to transfer function models for forecasting, a condensed description of their mathematical background can be prepared. Future research might address this class of models, since the process of identifying them seems to hold more promise for being automated than does the process of identifying the Box-Jenkins transfer function models.

3 APPLICATIONS IN LITERATURE

There are a number of precedents for using forecasting approaches to anticipate demand for electric power. Many papers on this topic have been published in *IEEE* Transactions on Power Apparatus and Systems*. Many investigations report successful prediction of power demand, based on historical information only, using the Box-Jenkins univariate models.

Keyhani and El-Abiad (1975) used an ARMA (1,0) model to make very-short-term forecasts from 1 minute data; they used ARMA (1,1) and ARMA (2,1) models on 5 minute data, and ARMA (2,0) models on hourly data. Keyhani and Rad (1977) used a form of dynamic regression, employing a lagged hourly temperature to forecast hourly loads. Vemuri, Balasubramanian, and Hill (1973) used an ARIMA $(0,1,1)x(0,1,1)_{12}$ model to forecast monthly peak loads. Hagan and Klein (1977) used Box and Jenkins models with a 24 hour period to forecast hourly loads with 1 to 4 hour lead times, using different models for each season of the year. Meslier (1978) used ARIMA $(1,0,0)x(0,1,1)_7x(0,1,1)_{365}$ models to forecast daily energy consumption 1 day ahead; apparently correction factors needed to be added to adjust for holidays.

Abu-El-Magd and Sinha (1981) compared Box-Jenkins models to state space models with regard to forecasting short term (5 minutes ahead) load demand. The predictive error was very similar for the two approaches, but the authors noted that the state space model could more easily be adapted to online prediction and model updating. Hagan and Behr (1987) used Box-Jenkins transfer function models (with temperature as the exogenous variable) to forecast 24 hour load curves for a 3 week period. They report average absolute forecast errors on the order of 5 percent.

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*Institute of Electrical and Electronics Engineers.

4 SOFTWARE CONSIDERATIONS

A number of different forecasting methodologies have been successfully employed, indicating the need for software tools that would facilitate the investigation of a variety of approaches. In recognition of this need, EPRI has sponsored the development of forecasting software to address the planning and control needs of the power industry.

Two software products available for the microcomputer would facilitate a thorough investigation of the feasibility of constructing forecasting models. One product is *Forecast Master*, developed by Stellwagen and Goodrich under agreement with the Electric Power Research Institute (EPRI). It is designed for research use and has a complete set of time series analysis approaches. *Forecast Master* has also been favorably reviewed by a major personal computing magazine.

Since a thorough knowledge of time series analysis methods is required to use *Forecast Master*, this program may be too complicated for many heat plant operators. Another software product by the same developer—*Forecast Pro*—is much more user friendly. A useful subset of the analysis methods in *Forecast Master* are included in *Forecast Pro*, but they are driven by an expert system to lead the user through the steps of model identification. This software was also favorably reviewed by the same computing magazine. *Forecast Pro* is well suited to the project at hand. It was developed to meet needs of EPRI, which are very similar to those of a central heat plant operator. Its major benefit is its expert system, which can construct models as accurate as those generated by an expert without requiring the user to be an expert.

5 DATA CONSIDERATIONS FOR THE PHASE 1 STUDY

In the Phase 1 study conducted at UIUC, steam flow data from two lines at Fort Benjamin Harrison (referred to as "Steam 1" and "Steam 2"*) were used with accompanying ambient temperature data. The data were collected at 30 second intervals and averaged to produce data at 5 minute intervals. Due to malfunctioning instruments or problems in boiler operations, erroneous data were recorded during several intervals. The erroneous data points were simply replaced with adjacent data. Since this problem did not occur frequently, the basic validity of the data was not compromised.

The next step was to aggregate the data into hourly data, which effectively smoothed the data in the process and reduced the impact of the corrections referred to above. The initial study focused on two data segments: the segment covering March 2 through March 28 and the one covering February 1 through February 28. The February segment was not the first choice for several reasons: there was a notable pressure drop in Steam 2 on the morning of 18 February, and there were some wide oscillations in Steam 1 on 8, 18, and 19 February. In contrast, both Steam 1 and 2 were relatively free of such anomalies throughout March, except for some oscillations in Steam 1 on March 12. Plots of the February and March data are provided in Appendix A, and tables of the data are provided in Appendix B.

An additional consideration was the desire to use data accompanied by temperature variations that would affect steam flow. The March data had such temperature swings, and since the Steam 2 data were the cleanest, they were chosen for the study. Some results will be given for the March Steam 1 data and for February Steam 1 and Steam 2 data (to be referred to as "the other three data sets"), but the level of detail provided will be less than that provided for the March Steam 2 data.

The number of data points is adequate for Box-Jenkins modeling since the March data had 648 points and the February data had 672. For ARIMA modeling, it is often suggested that the number of points be greater than 30 and less than 2000. Extra data points simply make the computations more lengthy without substantially improving the estimation of the parameters in the models (Box, 1970). Fewer data points make the parameter estimates more uncertain.

* In the Phase 2 study these lines are called the "Alpha" and "Beta" lines, respectively, which are their official designations at Fort Benjamin Harrison.

6 MODELING RESULTS FROM THE PHASE 1 STUDY

Stationarity and Seasonality

The first step in identification of the forecasting model for the March Steam 2 data was to examine its autocorrelation function (ACF). It was found that this function is significantly different from zero for lags up to 20 periods (hours). This indicated a need for differencing. The ACF of the differenced series died out much more rapidly but had a significant value at a lag of 24, indicating the patterns seen in the data. The obvious transformation is to apply seasonal differencing with a period of 24. When this was done the ACF was marginally acceptable as white noise (p=0.028) except for a persisting component at a lag of 24. Since some seasonal models were to be entertained, it was decided to proceed with the data as stationary after a differencing operation $\nabla\nabla_{24}$. As might be expected, this same differencing had the same effect on the other three data sets, making the ACF function more nearly resemble that of white noise.

Transfer Function Employing Temperature

Although various Box-Jenkins univariate models were considered at this point, a transfer function model was preferred in order to capture the change in steam load due to temperature variation. Indeed, the correlation between the steam flow z_t and the temperature x_{t-k} is 0.89 when k=0, 0.88 when k=1, and 0.87 when k=2. One explanation for these results is that they simply indicate the high level of autocorrelation found in each of the time series for steam flow and temperature. However, we know from basic physical considerations that steam flow is correlated with temperature. It was also noted that the correlation between the differenced series was also considerable, so there was an inducement to proceed with such models.

As a practical matter, forecasting 2 hours ahead was desired. These forecasts therefore needed temperature values 2 hours ahead, something that only weather forecasts could provide. Although this kind of model was used, the time series for temperature also lagged by 1 to 2 hours so the model did not need a temperature forecast as an input.

To identify a model where the input series lagged with c=0, 1, and 2, the following fairly general form of the Box-Jenkins transfer function model (from Eq 26) was used:

$$\nabla\nabla_{24}\, z_t = \left[\omega(b)/\delta(b)\right]\nabla\nabla_{24}\, x_{t-c} + \left[\theta(b)\Theta(b^{24})/\phi(b)\Phi(b^{24})\right]a_t$$

The approach used was to examine the ACF and partial autocorrelation function (PACF) of the residual series in order to determine the type and order of backshift polynomials needed to reduce the residual series to white noise. The partial autocorrelation function represents the results of regressing the series on its first lag, then on its first two lags, and so on until the last lag introduced into the series turns out not to be statistically significant. The ACF and PACF provide clues as to the autoregressive order and the moving average order of the process. The references by Box and Jenkins (1970) and by Goodrich (1989) discuss this in great detail.

Two quantitative measures of goodness of fit were used. First a chi-square test was automatically carried out in *SAS* to test the hypothesis that the residual series is white noise; the higher the calculated significance level (the "p" value) is, the less likely it is that the hypothesis should be rejected. Often statisticians use a p value of 0.05 or 0.10 as a lower cutoff for the significance level. Second, the AIC was calculated; the smaller it is, the better the fit is. These two measures complement each other, since the excessive inclusion of parameters in the model will invariably result in a higher p value for the chi-square test, but will also increase the AIC because of "overfitting."

When the temperature series lagged by 2 hours (c=2), the model with the following form left a residual series that could not be rejected as white noise (p=0.71) and had an AIC of 10095:

$$\omega(b) = -49.2 \qquad \phi(b) = (1-.140b^4)$$
$$\delta(b) = 1 \qquad \Phi(b^{24}) = 1$$
$$\theta(b) = (1+.120b)$$
$$\Theta(b^{24}) = (1-.671b^{24})$$

The moving average terms were included to correspond to the order of the differencing, as suggested earlier in Eq 20. The autoregressive term at lag four was included because of a persistent term in the autocorrelation of the residual series. There is a certain element of trial and error to the development of model structure since an analyst is motivated by the autocorrelation function of the residual series with the model. Once the model was chosen, however, the values of all coefficients were automatically obtained by an algorithm that maximizes the likelihood function. (A printout of the results of the model specification is available from the authors for review.)

So the transfer function model takes the form

$$\nabla\nabla_{24}z_t = -49.2\,\nabla\nabla_{24}x_{t-2} + \left[(1+.120b)(1-.671b^{24})/(1+.140b^4)\right]a_t \qquad \text{[Eq 29]}$$

when the input (temperature) series is lagged by 2 hours. A variety of other model formulations were attempted, but the chi-square results and the AIC were not as encouraging. For instance, if the MA(1) and AR(4) terms are omitted, the measures of goodness of fit deteriorate with p=0.20 and AIC=10111. If too many additional terms are included, the AIC eventually increases, but there is another indication that the terms are unneeded. That is, the standard deviation of the estimate of the parameter turns out to be so large that the estimated parameter value cannot be claimed to be significantly different from zero.

When based on a temperature series lagged by 1 hour (c=1), the estimated model takes the form

$$\nabla\nabla_{24}z_t = -63.6\,\nabla\nabla_{24}x_{t-1} + \left[(1+.0946b)(1-.672b^{24})/(1+.129b^4)\right]a_t \qquad \text{[Eq 30]}$$

with residuals acceptable as white noise (p=0.79) and an AIC of 10105. When the current temperature (c=0) is used, the model takes the form

$$\nabla \nabla_{24} z_t = -145.2 \nabla \nabla_{24} x_t + \left[(1 + .0749b)(1 - .657b^{24})/(1 + .142)b^4)\right] a_t \qquad \text{[Eq 31]}$$

with residuals acceptable as white noise (p=0.946) and an AIC of 10078. Apparently the last model is superior to the others in terms of fitting the historical data without overfitting due to using too many parameters. However, as mentioned earlier, the forecast of z_{t+k} would require x_{t+k} be given. Thus the forecast k hours ahead for steam demand would require that the temperature be forecast k hours ahead and input to the forecast equation. As an alternative, the lagged temperature models were retained and compared in terms of forecast error.

To verify the transfer function model, an identification process was begun by "prewhitening" the temperature series. The model identified was

$$(1 - .65b) \nabla \nabla_{24} x_t = (1 - .21b)(1 - .90b) a_t \qquad \text{[Eq 32]}$$

which left a residual series as white noise (p=0.49). If this prewhitening transformation is then applied to the steam flow data, the cross correlation between the prewhitened input and transformed output can be used to identify the terms in the transfer function. In fact, this was done and the transfer function was found to have the simple form indicated in Eq 31, with steam flow being directly proportional to temperature (possibly lagged slightly).

Models From the Literature

To further verify the modeling effort reported in the section above, a number of model forms found in the literature were considered and the appropriate parameters estimated to specify the model. The models reported by Hagan and Klein (1977) were attempted first. The standard deviations of several of the parameter estimates were 300 percent of the estimates themselves. A number of variations were attempted, eliminating parameters until the model reduced to the model given in Eq 31.

The Hagan and Behr (1987) formulation was also attempted, with the initial result being that the parameter estimation scheme did not converge. Only when the model was put essentially in the form of Eq 31 did the parameter estimates converge and the residuals approach white noise.

The models suggested by Keyhani and Rad (1977), which are similar to dynamic regression in form, were specified and parameters estimated. An example of the kind of result obtained is

$$(1 - 1.18b + .21b^2 - .17b^{24} + .164b_5^2) z_t = 20592 - 44.4 x_{t-3} \qquad \text{[Eq 33]}$$

resulting in a test of residuals for white noise with p=0.065 and an AIC of 10389. No forecasting was performed with this model since the goodness of fit test results were inferior to the model already obtained.

None of the approaches mentioned in the literature appeared to be more promising than the models described in Eqs 29, 30, and 31, obtained by applying fundamental Box-Jenkins principles to the data at hand.

Models for the Other Three Data Sets

A few results will be given for the other three data sets to indicate the robustness of the model form suggested for the March Steam 2 data. The results of forecasting with these models will be provided in Chapter 7, where they can easily be compared with one another. For the March Steam 1 data, the model identified for the temperature lagged by 2 hours was

$$\nabla\nabla_{24}z_t = -83.2\,\nabla\nabla_{24}x_{t-2} + \left[(1+.887b)(1-.885b^{24})/(1+.284b+.175b^{13})\right]a_t \qquad \text{[Eq 34]}$$

The fit was not as good for these data since p=0.12 in the chi-square test for the residuals. When the February Steam 2 data were modeled, the following transfer function model was identified:

$$\nabla\nabla_{24}z_t = -48.7\,\nabla\nabla_{24}x_{t-2} + \left[(1+.124b)(1-.938b^{24})/(1+.10b^2+.258b^8)\right]a_t \qquad \text{[Eq 35]}$$

with a chi-square test of the residuals giving p=0.35. Finally the February Steam 1 data were modeled and the following transfer function model was identified:

$$\nabla\nabla_{24}z_t = -79.2\,\nabla\nabla_{24}x_{t-2} + \left[(1-.828b)(1-.905b^{24})/(1+.164b^2)\right]a_t \qquad \text{[Eq 36]}$$

with p=0.56 for the test of the residual series as white noise. The AIC values were not given here because it only makes sense to compare AIC for different models obtained from the same data set. Although it may appear that these models are equally as attractive as Eq 29 for the March Steam 2 data, it will be shown in Chapter 7 that the forecast errors turn out to be larger. Some of this difficulty may be attributed to the problems with the other three data sets, as discussed in Chapter 5.

7 FORECASTING RESULTS FROM THE PHASE 1 STUDY

The models for March Steam 2 data specified by Eqs 29, 30, and 31 were used to forecast 1 hour ahead for the last week of March. A sample *SAS* printout for Eq 29 is available from the authors for review. The standard deviation of the 1 hour ahead forecast error, σ_e, is used as a quantitative measure of predictive accuracy. For temperature lagged by 2 hours (Eq 29), σ_e=611; for temperature lagged by 1 hour (Eq 30), σ_e=618; and for temperature not lagged (Eq 31), σ_e=607. The mean of the forecast for the last week of March was 14443, so the standard deviation of the forecast error is only about 4 percent of the value of the forecast. This result is very encouraging and indicates that accurate forecasts up to a few hours ahead could likely be obtained with similar transfer function models.

Forecasting results for the models identified for the other three data sets are not as encouraging. For March Steam 1 (Eq 34), σ_e=549. This is not an encouraging result since the mean forecast for this line for the last week of March is 4589. Therefore, the standard deviation of the forecast error is about 12 percent of the mean value of the forecast. For February Steam 2 (Eq 35), σ_e=1701, which was about 9 percent of the mean value of the forecast (18487). Finally, for February Steam 1 (Eq 36), σ_e=926, which was about 11 percent of the mean value of the forecast (7997).

At this time it is not known with certainty why the models' forecast errors for the other three data sets are so large. The most likely reason seems to be the quality of the data, as discussed in Chapter 5. The March Steam 2 data was initially chosen for the most thorough investigation because it had the fewest obvious anomalies. In order to use the other data sets, it would have been necessary to repair large segments of the records, making it difficult, therefore, to interpret the results of the model fitting effort.

Once a predictive model is online, it might prove effective to replace aberrant data segments with the predicted values until either a malfunctioning sensor is repaired or a problem in boiler operations is rectified. The upper and lower 95 percent confidence limits provided by the model could aid in the identification of such a problem with incoming data.

The process of fitting the model to a segment of the data and then comparing the predictions to the actual values was not carried out here as it would not have been informative. The *SAS* software package requires that an ARIMA model be fitted to the input series—temperature, in this case—so that the temperature values are available for use in future forecasts. Such an ARIMA model was constructed during the prewhitening of the series to validate the transfer function model. Unfortunately, if this model is used to produce forecasts 1 week ahead, it will be impossible to discern how much of the forecast error is caused by inaccurate temperature prediction and how much is due to the forecast model itself. In practice of course, a recent temperature measurement is usually available, and such a forecast temperature would not be used. In fact, based on a temperature measurement that is lagged by 2 hours, the transfer function model predicts steam flow well.

8 RESULTS FROM THE PHASE 2 STUDY

Models Considered

During Phase 2 of this research, *Forecast Pro* software was used for model building and forecasting. As mentioned before, this software serves the planning and control needs of the utility industry with a built-in expert system to lead users through the steps of model identification. The following models were considered by this software:

1. Exponential smoothing
   a. Simple exponential smoothing
   b. Holt two parameter exponential smoothing
   c. Damped two parameter exponential smoothing
   d. Winters three parameter exponential smoothing
   e. Damped three parameter exponential smoothing
2. Box-Jenkins univariate ARIMA
3. Dynamic regression.

Since descriptions of these models are provided in the software manual, only highlights will be presented here.

Exponential Smoothing Models

Exponential smoothing techniques are easy to use and to understand conceptually. This model should be used when the data will not support a correlational approach like Box-Jenkins or dynamic regression. This can happen when either the historical data are too short to support accurate calculation of correlational coefficients or the correlations are not stable. A comprehensive review was written by Gardner (1983), who classified 17 basic methods. *Forecast Pro* includes five methods from the Holt-Winters (Holt, 1957; Winters, 1960) family. The empirical evidence cited by Gardner favors these five methods over the others. The time series is assumed to be modeled by one, two, or three components that represent the level, trend, and seasonality of the series. If the model includes a trend, then that trend is either forecasted linearly into the future, or forecasted as a damped exponential that eventually dies out to a constant level. Each technique uses recursive equations to obtain smoothed values for model components. Thus simple smoothing uses one equation (level), Holt smoothing uses two (level and trend), and Winters uses three (level, trend, and seasonal).

Box-Jenkins Univariate ARIMA Model

Box-Jenkins univariate ARIMA procedures were implemented in *Forecast Pro.* The main requirement for Box-Jenkins is that the data have a stable autocorrelation function. Exponential smoothing is a better choice if the autocorrelation functions are not stable or the data are too short—say less than 40 points. If there are significant leading indicators, then a dynamic regression model might be the preferred choice. The Box-Jenkins ARIMA (p,d,q) model is shown below:

$$P(B)(1-B)^{d}Y_{t} = Q(B)e_{t}$$

where B is backward shift operator
P(B) is autoregressive polynomial of order p
Q(B) is moving average polynomial of order q
Y_t is observed value at time t
and e_t is one-step forecast error.*

Box-Jenkins models the autocorrelation function of a stationary time series with the fewest possible parameters. It includes moving average terms that dynamic regression does not, and thus, theoretically, will produce the optimal univariate model. The major difficulty is to decide which ARIMA (p,d,q) model best fits the data. The *Forecast Pro* expert system will identify the degree of differencing d, the autoregressive order p, and the moving average order q automatically by minimizing the BIC criterion. It is recommended that automatic Box-Jenkins always be used first. If it is suspected that a better model can be obtained, variations around the automatic model can be tried next, and then the BIC criterion can be used to make the final selection.

Dynamic Regression Model

Dynamic regression should be used when the data are numerous enough and stable enough to support a correlational model. With inclusion of explanatory variables, dynamic regression will generally provide a definite increase in accuracy of fit. The dynamic regression model (Goodrich, 1989) is shown below:

$$R(B)\ P(B)\ Y_t = R(B)\ (\beta * Xt + Const) + e_t$$

where X_t is explanatory variable value at time t
β is coefficient of X_t
R(B) and P(B) are autoregressive polynomials
and Const is constant.

Modeling Results Using *Forecast Pro* Software

Both Alpha (Steam 1) and Beta (Steam 2) line flows measured at Fort Benjamin Harrison in March 1989 were used separately to build three models mentioned previously (Winters' three parameter smoothing, Box-Jenkins, and dynamic regression) using the *Forecast Pro* software. Four hundred eighty hourly average Alpha line steam flows from 2 March through 21 March, and the heating degree hours (65 minus the ambient temperature in degrees Fahrenheit**) are plotted in Figures A1 through A4.*** Steam flows calculated from the Box-Jenkins and dynamic regression models are shown (labeled BJ and DR respectively). As can be seen, the steam flow increased with increasing heating degree hours. Steam flow calculated from the dynamic regression model appeared to closely match the measured value. Forty-eight

* Note that this is the same model given in Eq 16, expressed in notation compatible with the software used in the Phase 2 study.
** 0.55(°F-32) = °C.
*** All figures and tables are presented at the end of this chapter. The following nonconventional numbering of figures and tables is used to facilitate data and error comparisons: items beginning with the letter A refer to Alpha line (Steam 1) data; items beginning with B refer to Beta line (Steam 2) data; items beginning with C offer various comparisons or summaries; the decimal numbers used on the rest of the items refer to the month and year those figures and tables represent.

and 23 March 1989 are also shown. Again, the forecast values matched nicely with those measured. The 48 hour forecast errors from the Box-Jenkins, Winters' three parameters, and dynamic regression models are plotted in Figure A6. Errors generated from the first 24 hour forecasts appeared to be about equal for all three models. However, errors for the last 24 hours stayed relatively small with the dynamic regression model, probably because the ambient temperature effect was taken into account in this model.

Similar results for Beta line flows are presented in Figures B1 through B6. Forty-eight hour forecast errors from the three models for the Beta line are about half of those for the Alpha line when Figure B6 is compared with Figure A6. Again, the three model forecasts showed similar errors during the first 24 hours, and for the last 24 hours, smaller errors were maintained with dynamic regression. The similarity observed for the two steam lines in terms of model fit and forecast error tend to confirm that all three models will do an adequate job for 24 hour forecasting. Only dynamic regression, which also requires weather information, is good for longer-term forecasting, however.

Beta line steam flows and ambient air temperatures measured at Fort Benjamin Harrison from February 1989 through September 1990 were then used to compare forecasts from Box-Jenkins and dynamic regression models using *Forecast Pro.* In each month, a model was built with up to 20 days' average hourly steam flows, and a 24 hour forecast was obtained. Only 20 days of flow values were used in this exercise because *Forecast Pro* can only handle a maximum of 480 data points for model building. The monthly model parameter values are listed in Tables C1 and C2 for Box-Jenkins and dynamic regression, respectively. The average percentages of errors for the 24 hour forecast are shown in the last column of these two tables, and also in Figure C1.

Actual Beta line steam flows and 24 hour forecast values obtained from Box-Jenkins and dynamic regression as well as the forecast errors are listed in Tables 2.89 through 9.90 for February 1989 through September 1990 whenever valid data were recorded. Data for June and July of 1990 were lost due to problems in telephone line communication. The 24 hour forecast errors for the data in Table 2.89 through 9.90 are plotted in Figures 2.89 through 9.90 for Box-Jenkins and dynamic regression models. A typical computer printout from *Forecast Pro* is shown in Appendix C using March 1989 flow data.

After examining the 20 month modeling results it was confirmed that Box-Jenkins and dynamic regression methods do an adequate job for 24 hour forecasting, with dynamic regression performing slightly better. Also, it appears that during a 24 hour forecasting period, if ambient temperatures do not show significant change, the forecast errors may be as low as 1 percent or less.

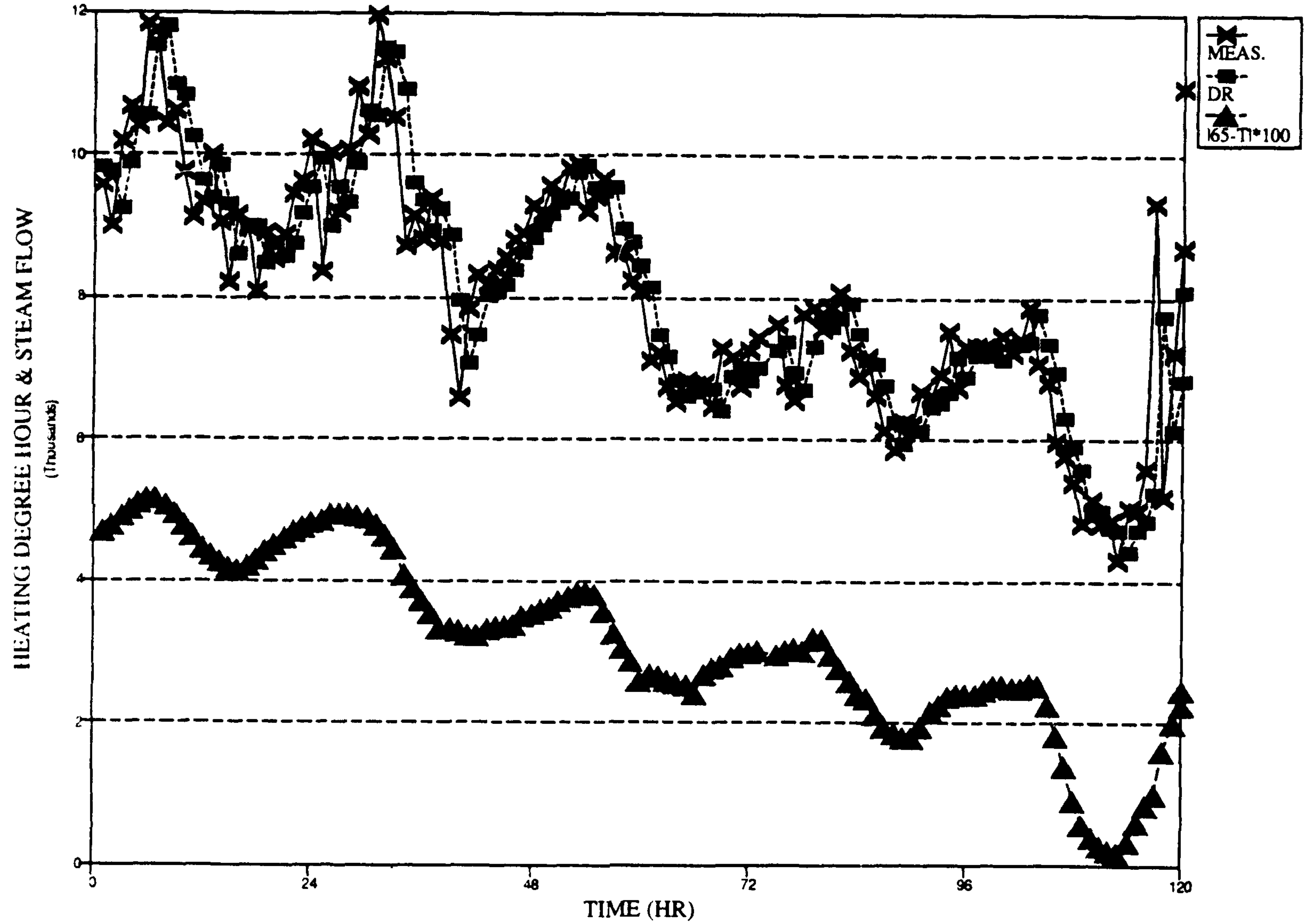

Figure A1. Alpha Line Steam Flow and Heating Degree Hours (3/2/89 to 3/6/89).

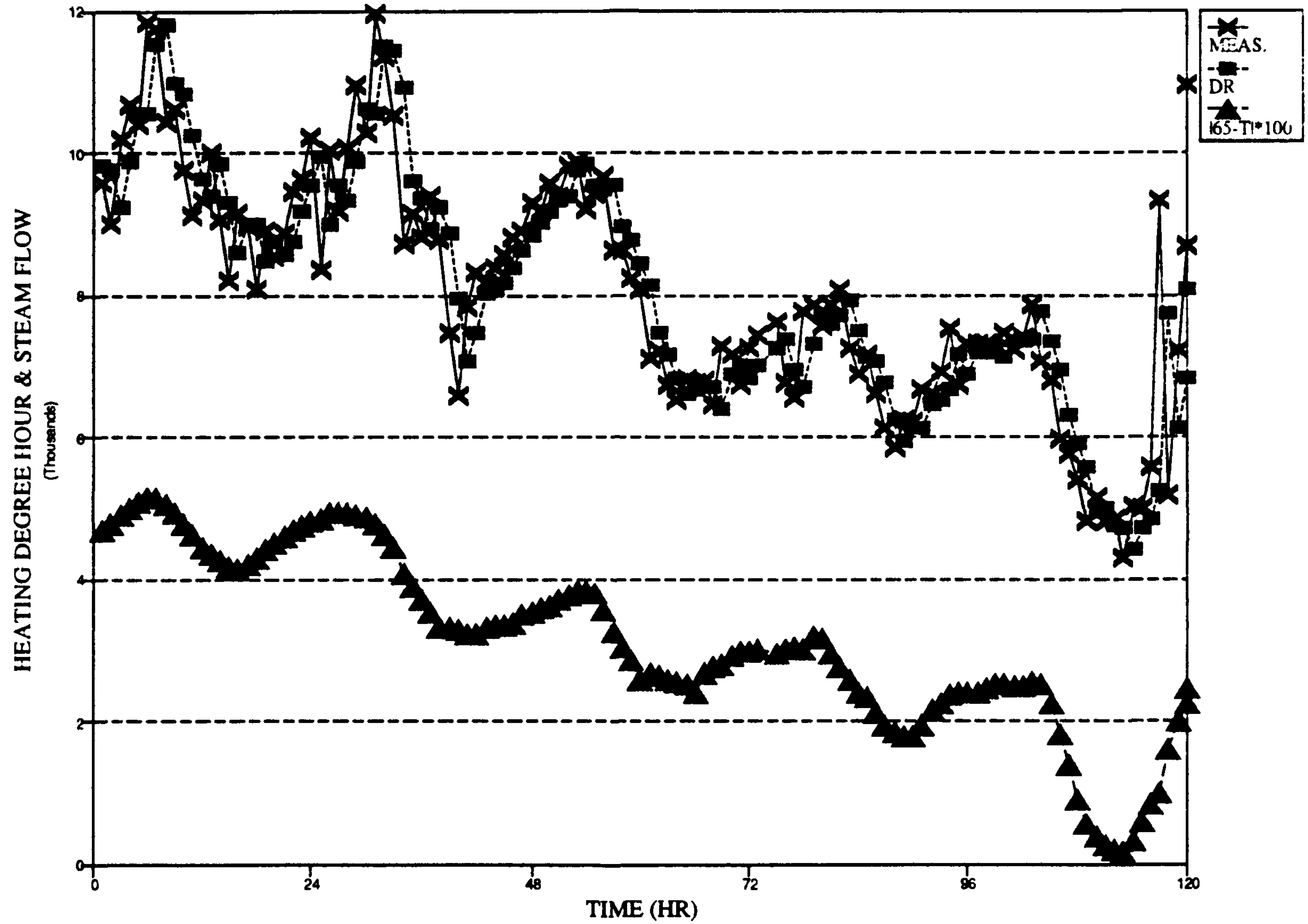

Figure A2. Alpha Line Steam Flow and Heating Degree Hours (3/7/89 to 3/11/89).

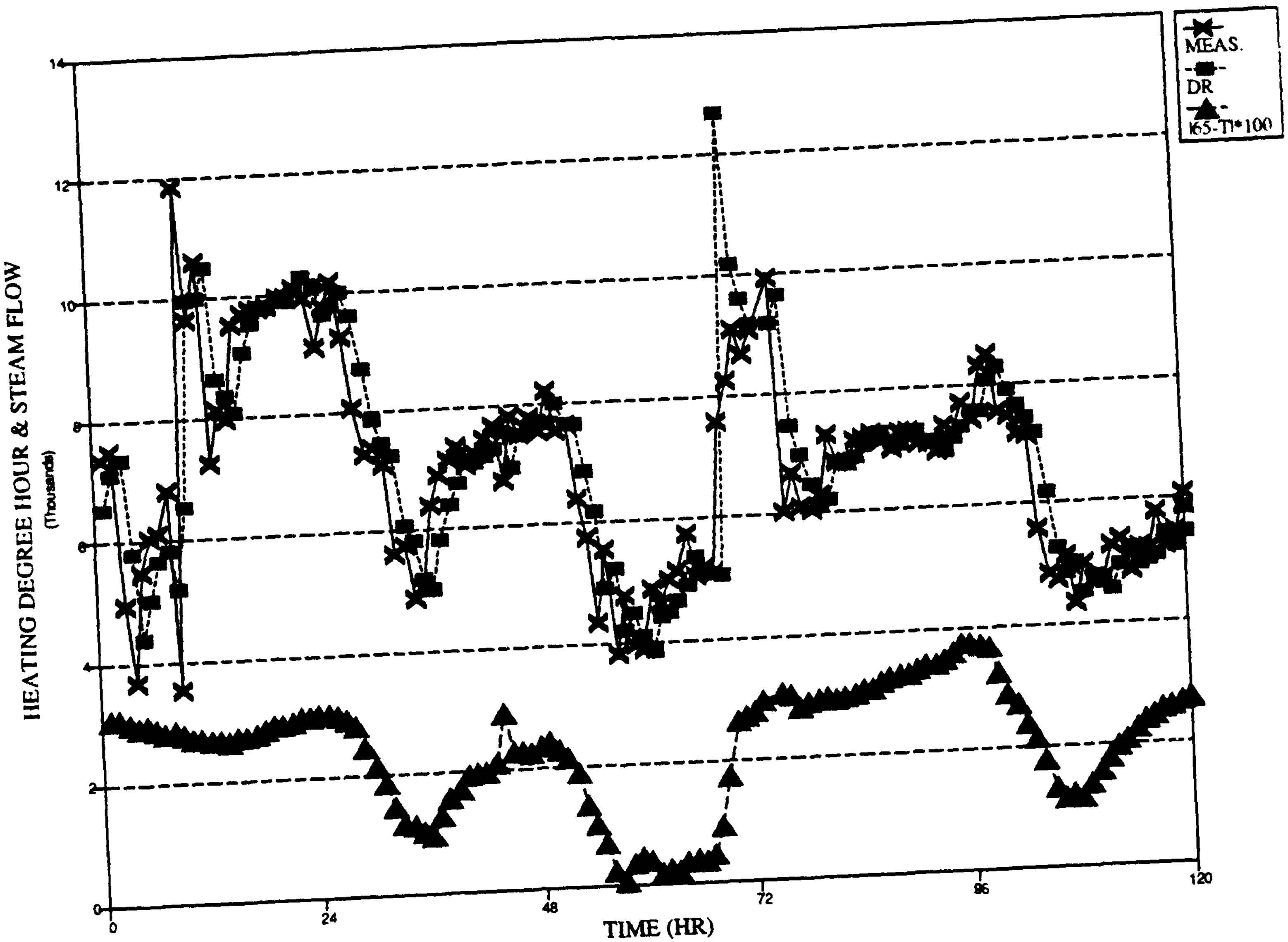

Figure A3. Alpha Line Steam Flow and Heating Degree Hours (3/12/89 to 3/16/89).

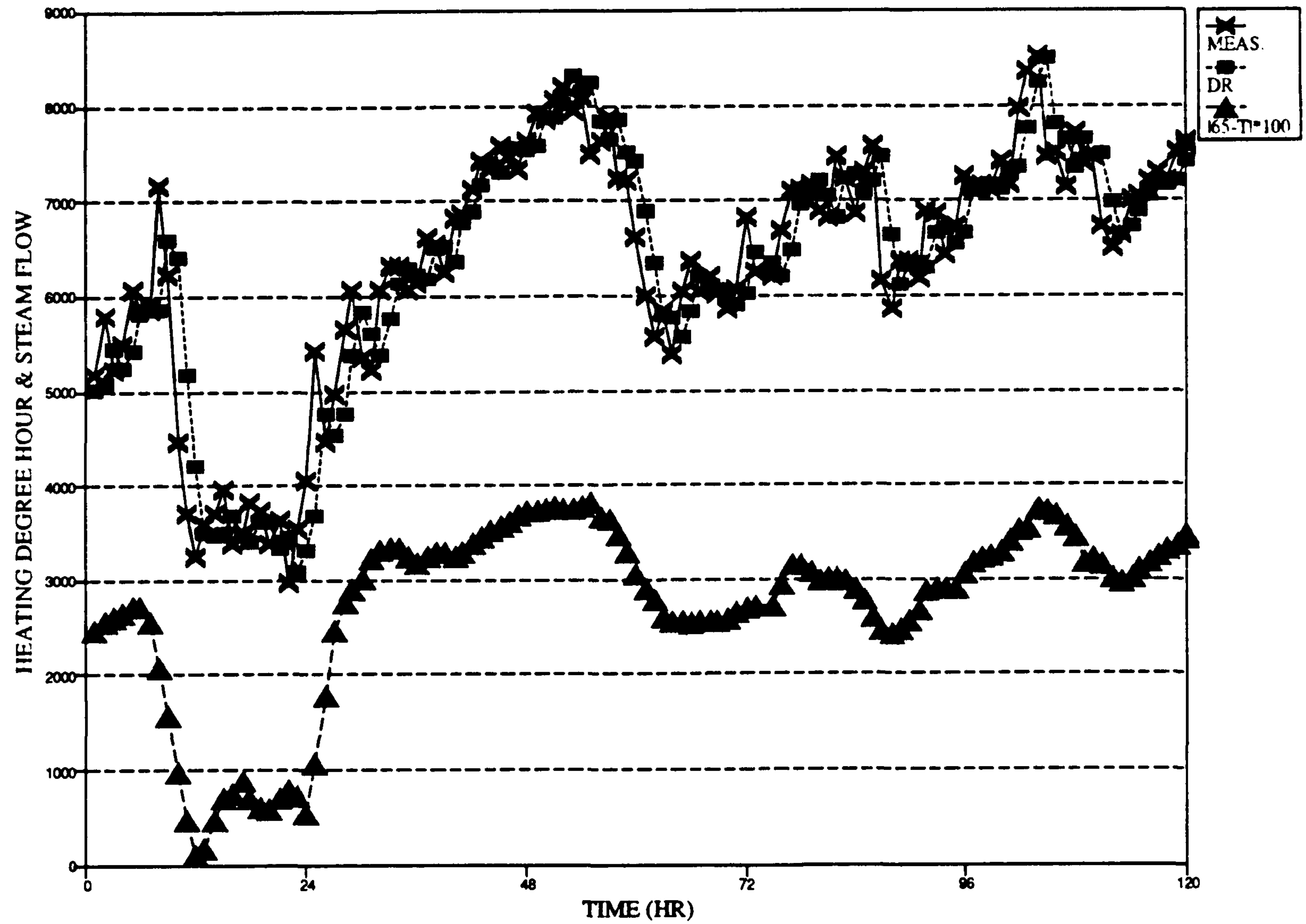

Figure A4. Alpha Line Steam Flow and Heating Degree Hours (3/17/89 to 3/21/89).

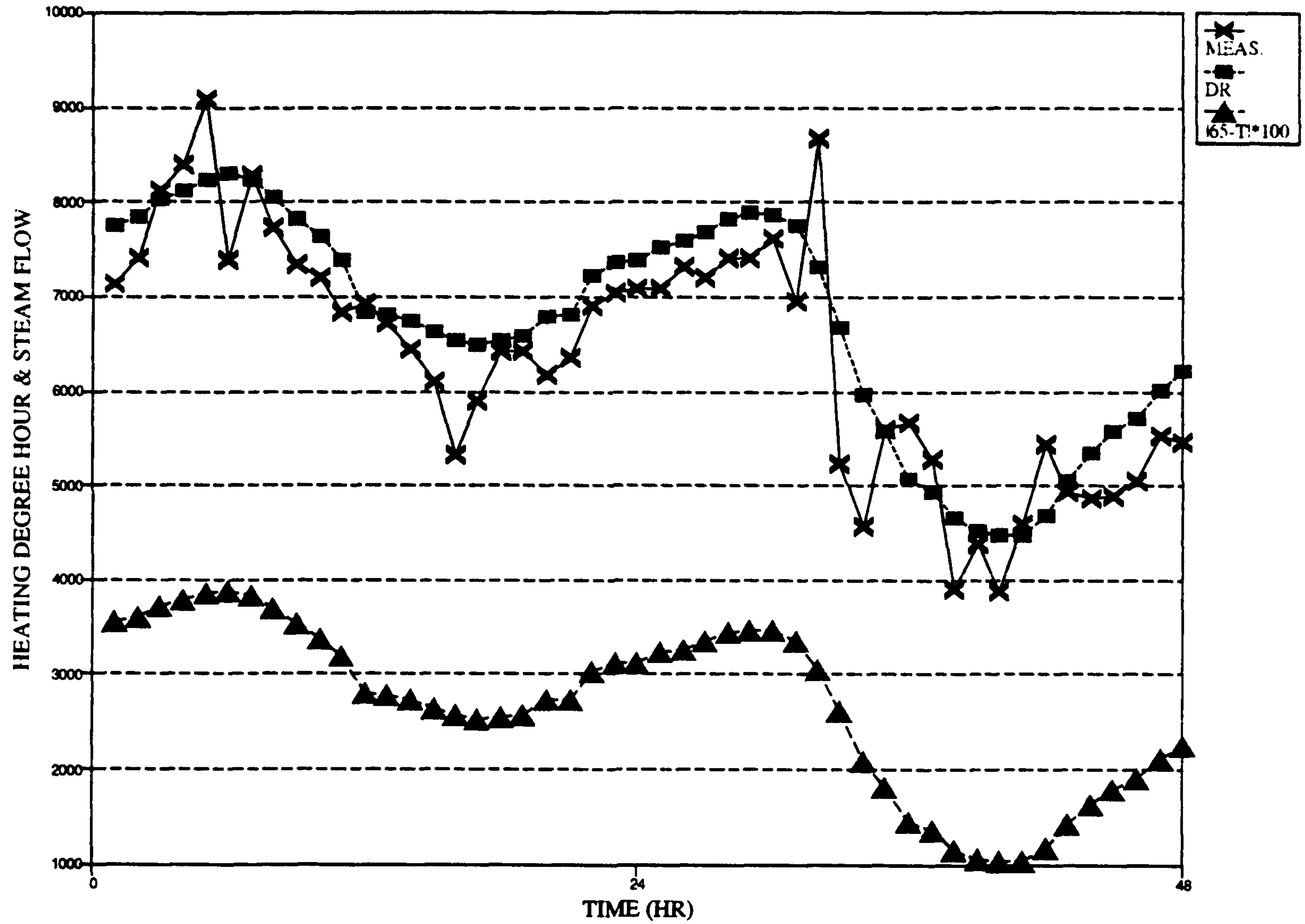

Figure A5. Alpha Line Steam Flow and Heating Degree Hours (3/22/89 to 3/23/89).

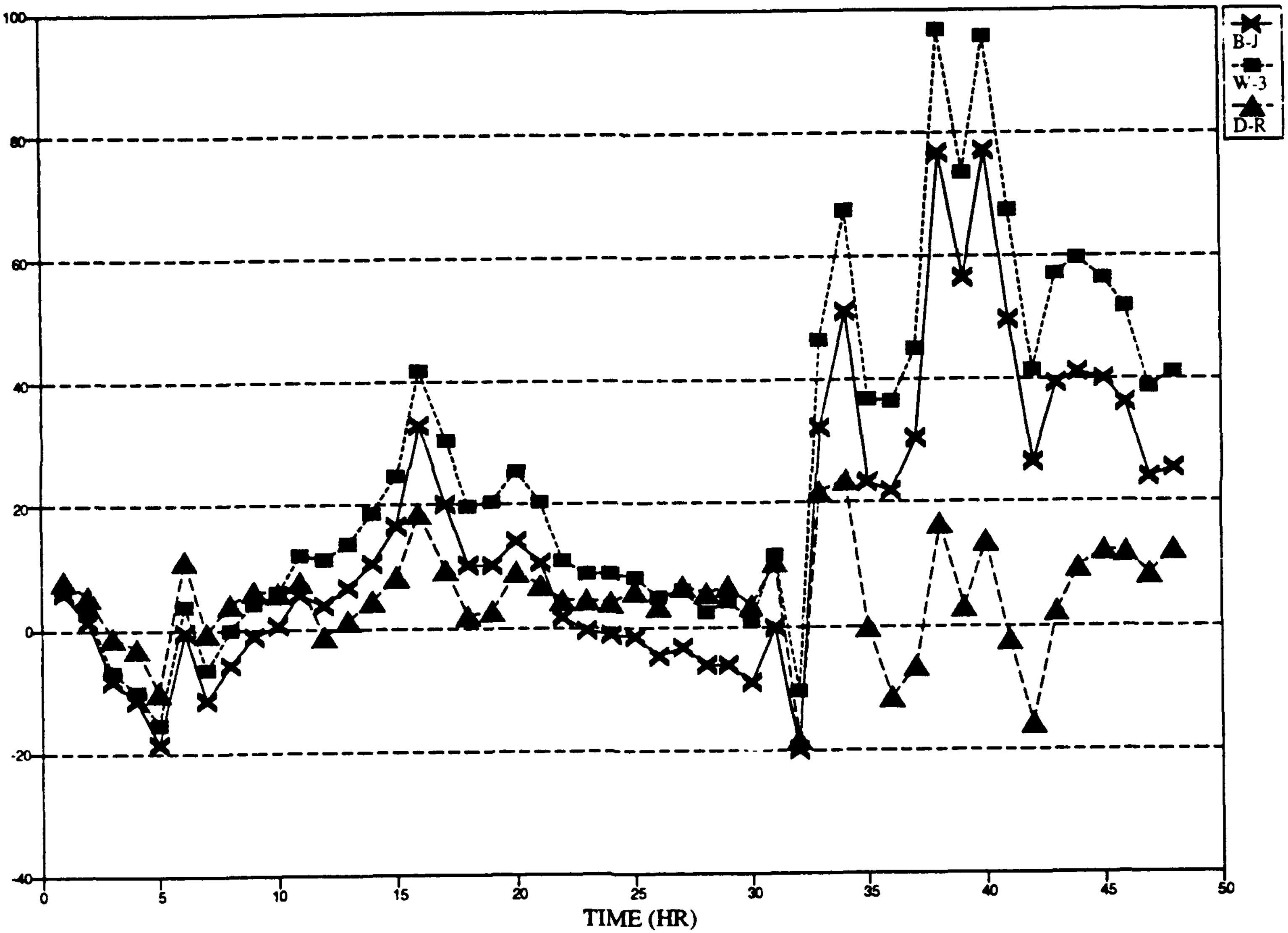

Figure A6. Percentage of Error From BJ, W3, and DR Models for Alpha Steam Flow (3/22/89 to 3/23/89).

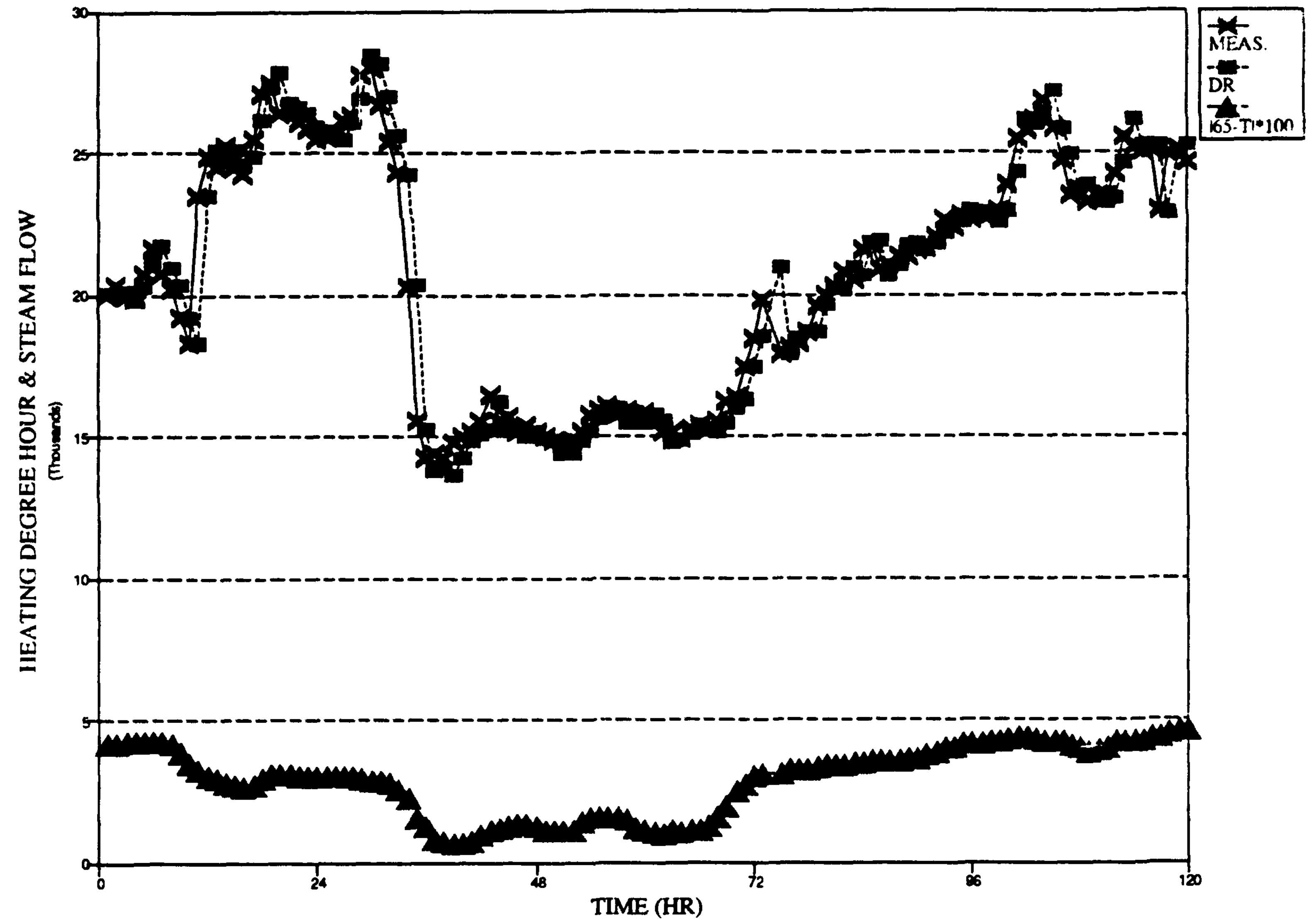

Figure B1. Beta Line Steam Flow and Heating Degree Hours (3/2/89 to 3/6/89).

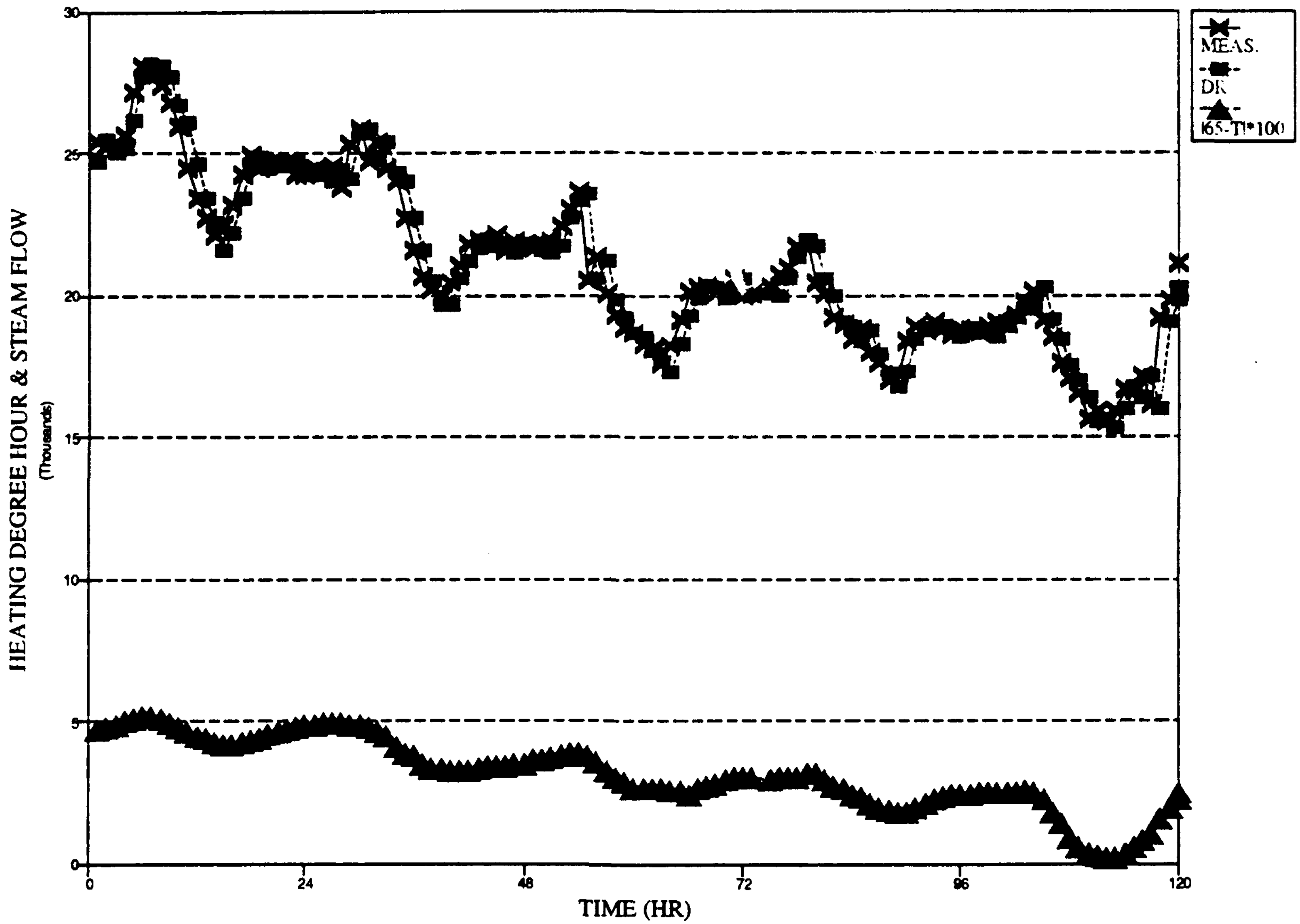

Figure B2. Beta Line Steam Flow and Heating Degree Hours (3/7/89 to 3/11/89).

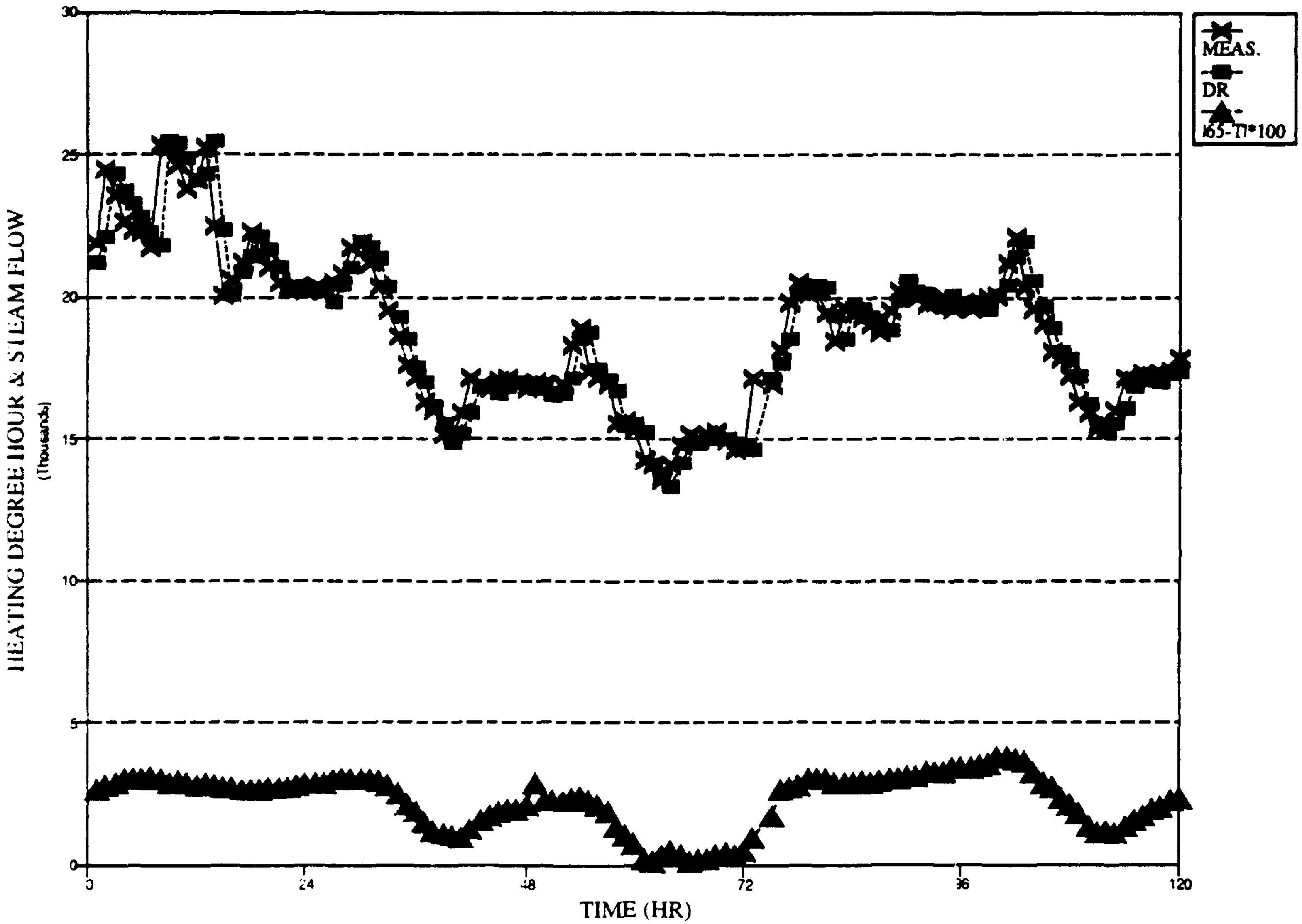

Figure B3. Beta Line Steam Flow and Heating Degree Hours (3/12/89 to 3/16/89).

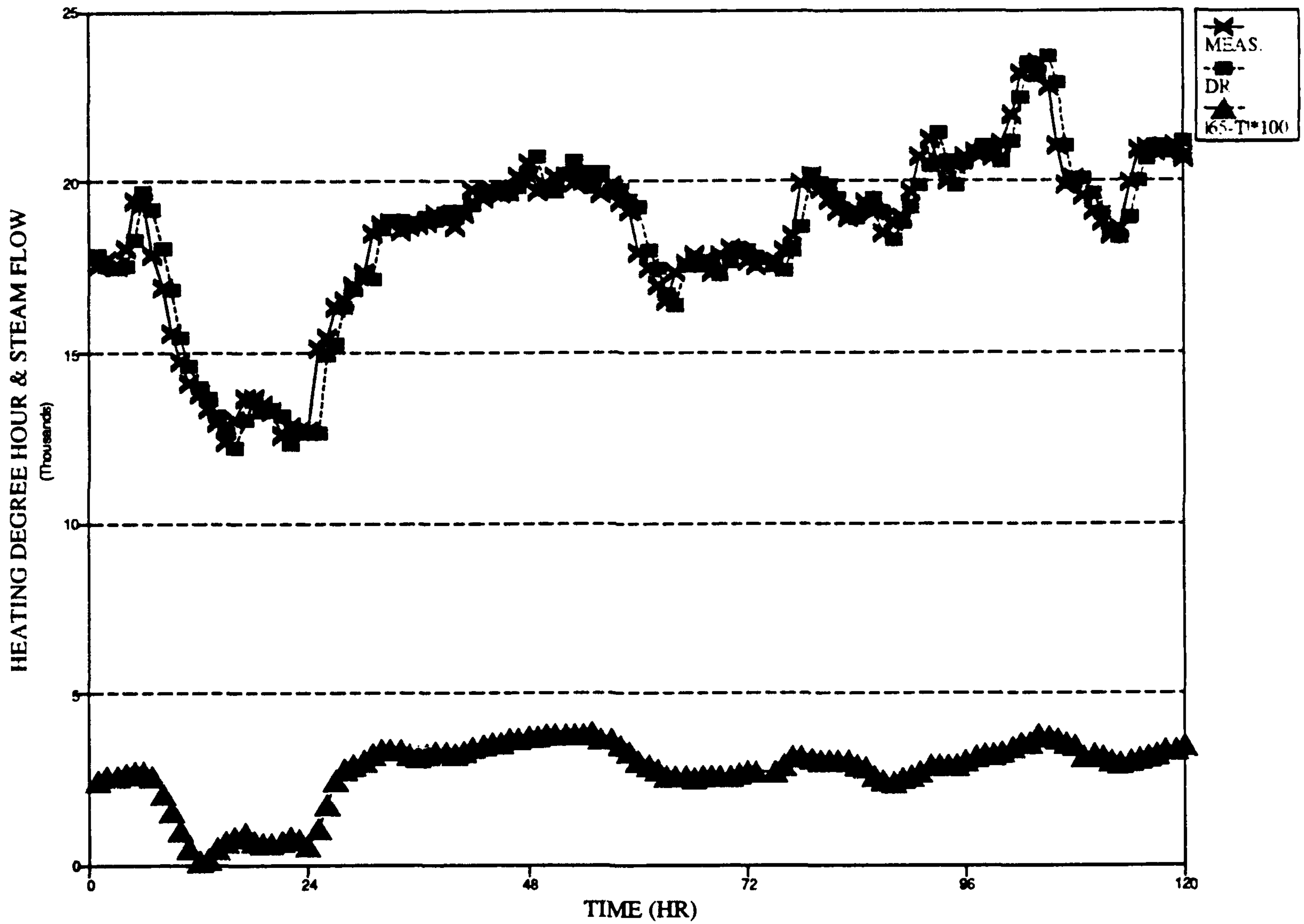

Figure B4. Beta Line Steam Flow and Heating Degree Hours (3/17/89 to 3/21/89).

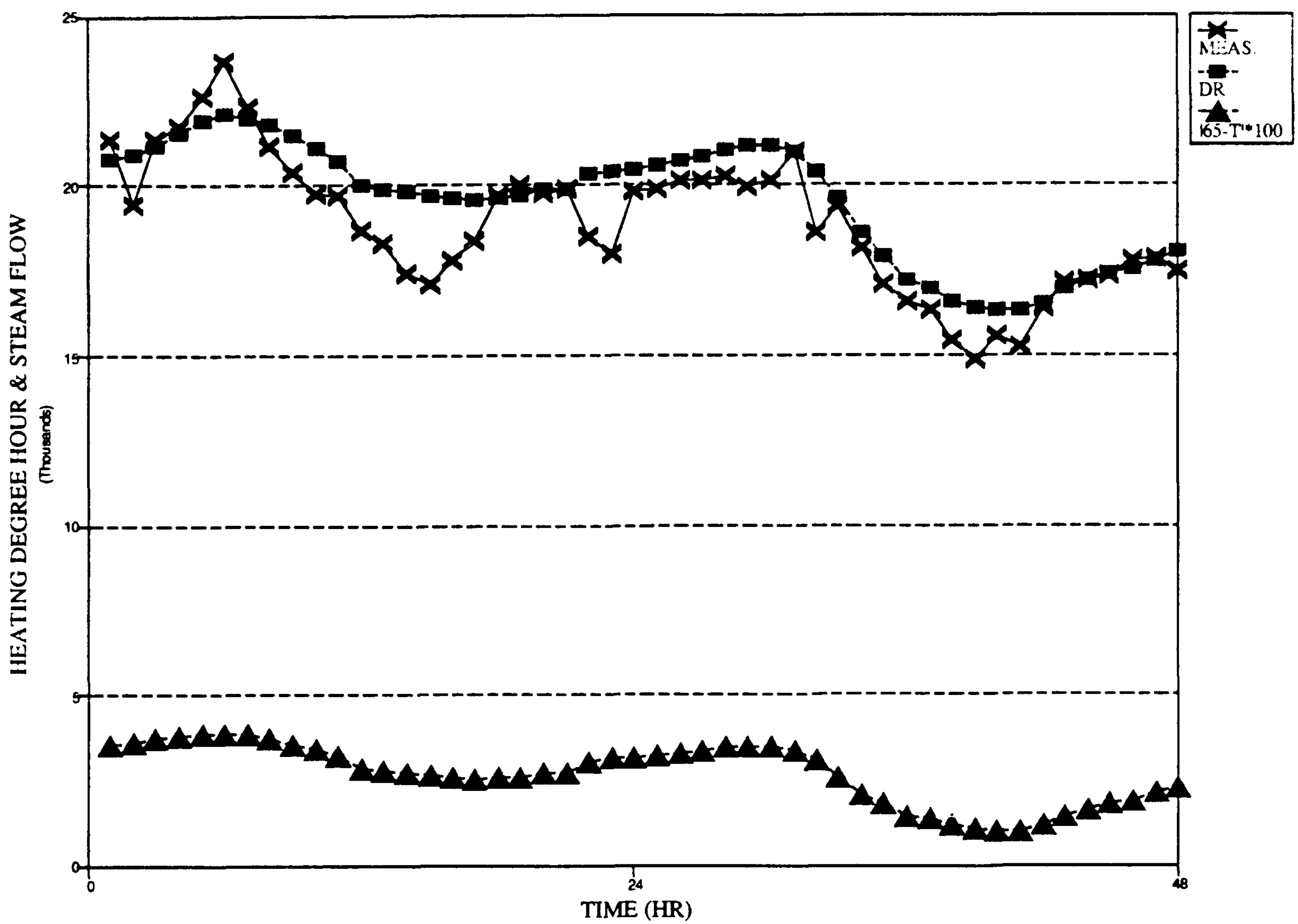

Figure B5. Beta Line Steam Flow and Heating Degree Hours (3/22/89 to 3/23/89).

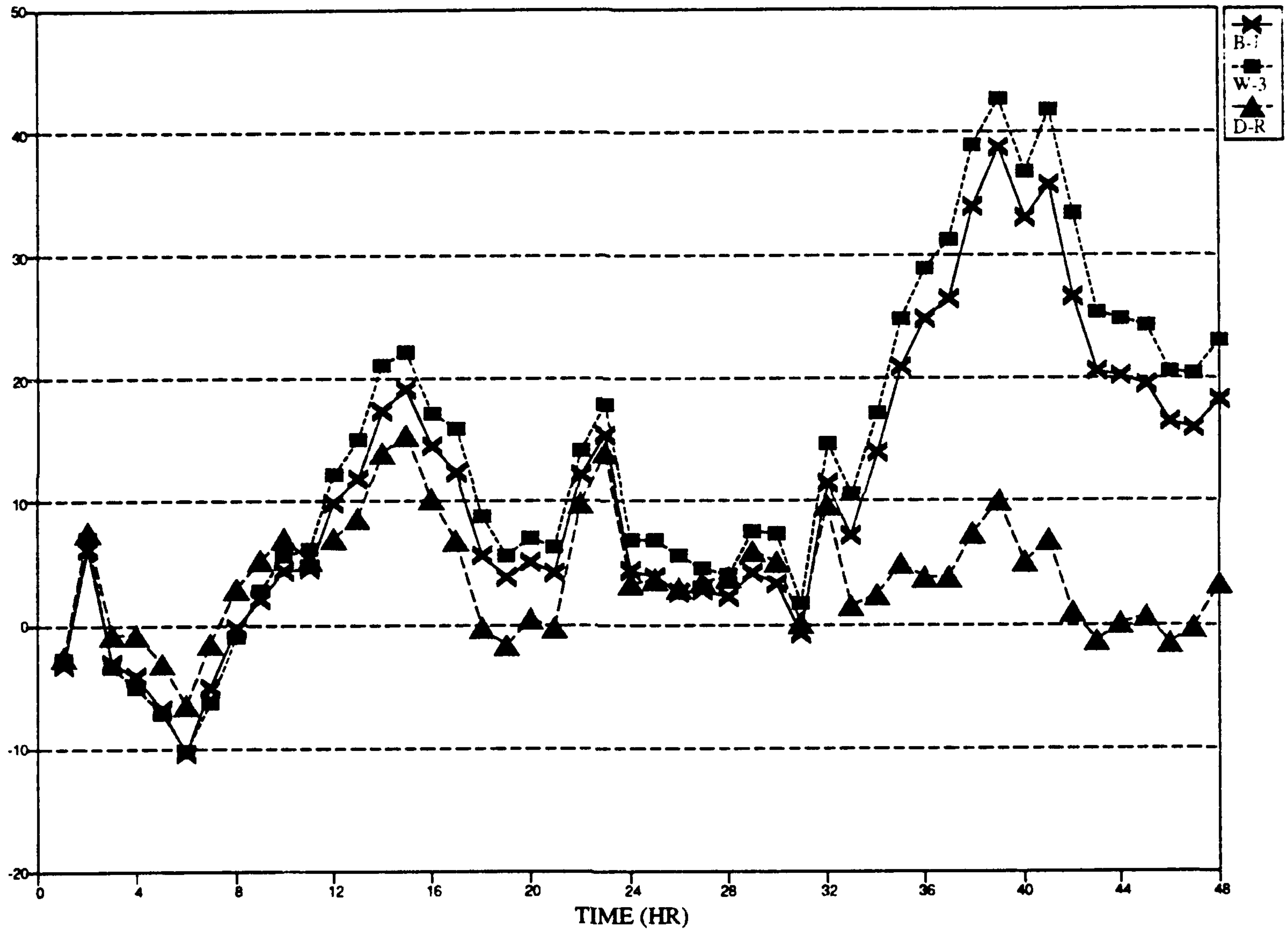

Figure B6. Percentage of Error From BJ, W3, and DR Models for Beta Steam Flow (3/22/89 to 3/23/89).

Table C1

Box-Jenkins Model, ARIMA (p,d,g)

DATA	P(B)	Q(B)	CONST	DIFF(d)	ERR(%)
FEB.89	1-0.892*B(1)-0.819*B(12)	1+0.217*B(1)-0.724*B(12)	404.762	0	-3.93
MAR.89	1-0.949*B(1)+0.057*B(12)	1	1133.51	0	-12.81
APR.89	1-0.942*B(1)	1	915.076	0	-13.13
MAY.89	1-.721*B(1)-.197*B(2)+.084*B(12)-.425*B(24)	1	720.244	0	-8.92
JUN.89*	1-0.890*B(1)	1	1652.88	0	-7.27
JUL.89*	1	1	13628.7	0	5.85
AUG.89*	1-1.096*B(1)+0.145*B(2)	1	605.136	0	1.02
SEP.89*	1-.874*B(1)+.196*B(2)+.016*B(12)-.283*B(24)	1	3149.4	0	-7.81
SEP.89	1-0.632*B(1)+0.045*B(12)	1	4623.64	0	-15.51
OCT.89	1	1+0.028*B(1)	0	1	2.29
NOV.89	1-0.075*B(12)	1-0.24*B(1)	0	1	9.02
DEC.89	1-0.896*B(1)-0.619*B(12)	1-0.208*B(1)-0.604*B(12)	1035.64	0	-6.15
JAN.90	1-0.879*B(1)	1	2328.81	0	-4.29
FEB.90	1-.02*B(12)-.068*B(24)+.007*B(36)-.231*B(48)	1	0	1	-10.09
MAR.90	1-0.843*B(1)	1	3215.85	0	-6.91
APR.90	1+0.403*B(1)	1	0	1	-2.41
MAY.90	1-0.954*B(1)+0.173*B(2)	1	2615.5	0	12.81
AUG.90*	1-1.190*B(1)+.304*B(2)+.076*B(12)-.490*B(24)	1	696.769	0	-7.35
SEP.90*	1-0.946*B(1)-0.002*B(12)-0.284*B(24)	1	346.185	0	0.33
SEP.90	1	1-0.337*B(1)-0.270*B(2)	0	1	0.09

Months with "" are based on cooling degree hour data.

Table C2

Dynamic Regression Model

DATA	P(B)	R(B)	BETA	CONST	ERR(%)
FEB.89	1-0.831*B(1)	1-0.197*B(1)+0.235*B(8)	55.604	1472.555	1.56
MAR.89	1+0.080*B(6)-0.144*B(7)+0.034*B(12)	1-0.596*B(1)-0.086*B(3)-.167*B(11)	288.752	10447.65	6.36
APR.89	1-0.936*B(1)+0.046*B(6)-0.011*B(24)	1-0.108*B(4)+0.164*B(10)	34.484	1097.491	-13.58
MAY.89	1-0.214*B(24)	1-0.456*B(1)-0.368*B(2)	125.959	8790.459	-2.21
JUN.89*	1-0.823*B(1)	1-0.181*B(1)-0.180*B(24)	-36.111	3096.475	-5.67
JUL.89*	1	1+0.047*B(24)	-17.617	13677.2	7.01
AUG.89*	1	1-0.945*B(1)	81.791	11779.49	1.57
SEP.89*	1-0.600*B(1)	1-.219*B(1)+.124*B(6)-.278*B(24)	28.301	5099.123	-6.48
SEP.89	1+0.086*B(5)	1-0.619*B(1)-0.074*B(6)	-30.458	13226.28	-12.68
OCT.89	1-0.983*B(1)	1+0.096*B(2)+0.149*B(7)	17.031	-2.112	7.56
NOV.89	1-0.135*B(24)	1-.599*B(1)-.188*B(2)-.112*B(5)	244.293	17181.98	1.71
DEC.89	1-0.611*B(1)-0.121*B(11)	1-0.173*B(3)+0.169*B(4)	79.015	3345.219	3.79
JAN.90	1	1-0.623*B(1)-0.229*B(3)	142.044	15232.97	-4.42
FEB.90	1-0.098*B(24)	1-0.945*B(1)	177.742	14706.1	-0.36
MAR.90	1	1-0.560*B(1)	304.244	10943.39	5.96
APR.90	1+.052*B(1)+.010*B(2)-.152*B(9)-.117*B(24)	1-.590*B(1)-.119*B(4)-.245*B(10)	136.971	9394.06	-4.41
MAY.90	1-0.725*B(1)-.143*B(9)	1-0.349*B910+0.206*B(8)	2.011	1574.187	7.54
AUG.90*	1+.092*B(8)+.142*B(9)+.130*B(11)-.300*B(24)	1-1.128*B(1)+.251*B(2)-.078*B(10)-.009*B(24)	28.044	9363.446	-1.02
SEP.90*	1-0.857*B(1)-0.194*B(6)+0.084*B(9)	1-0.166*B(1)-0.106*B(24)	0	301.414	0.18
SEP.90	1-0.608*B(1)-0.170*B(3)-0.194*B(7)	1-0.142*B(5)	0	246.312	0.04

Months with "" are based on cooling degree hour data.

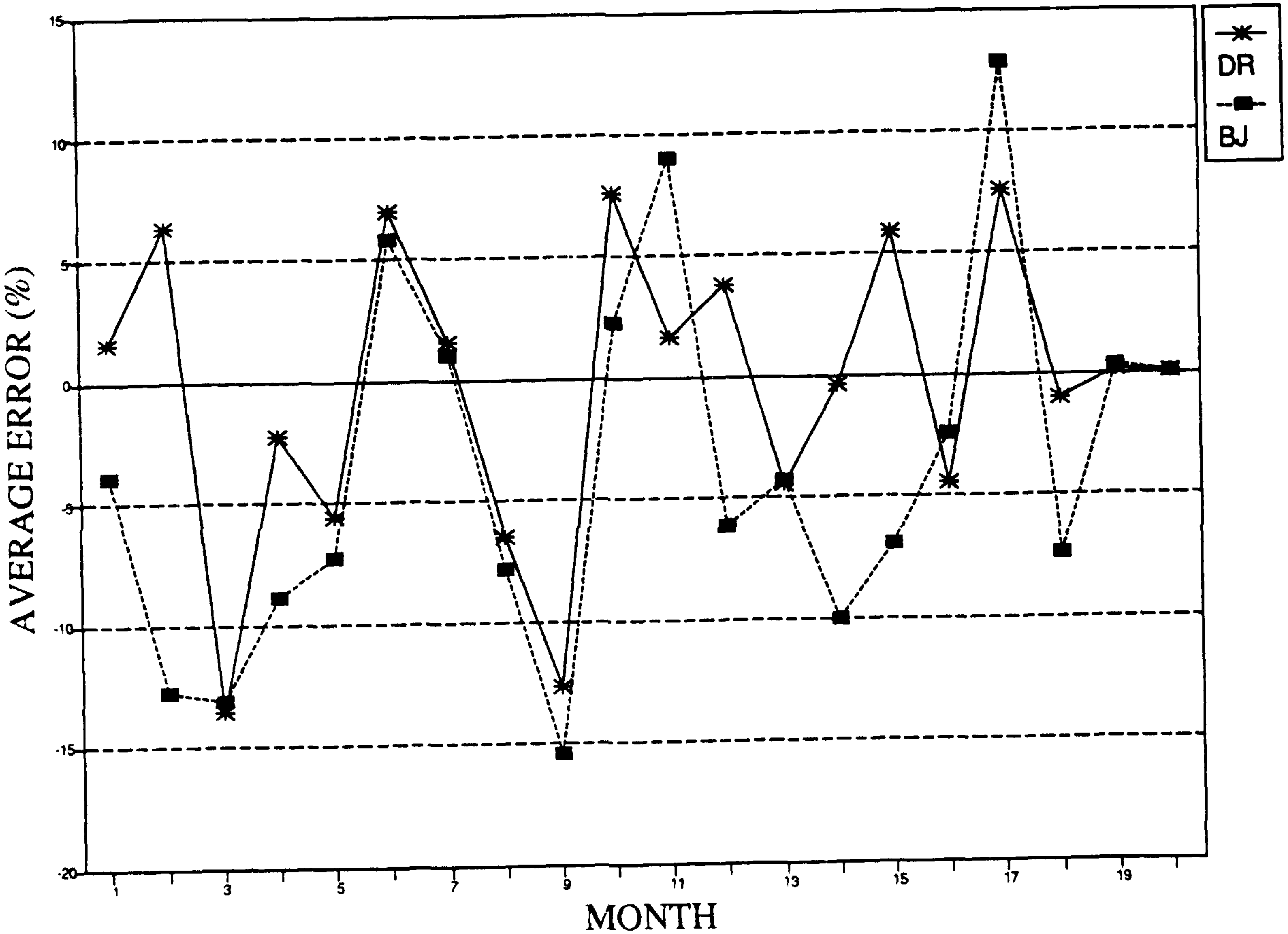

Figure C1. Forecast Steam Flow Error by DR and BJ Models.

Table 2.89

Measured and Model-Predicted Steam Flow Data for February 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	17590.3600	17862.6152	18646.7813	-1.5478	-6.0057
1	17532.0000	17858.4375	18776.7227	-1.8620	-7.0997
2	17439.5800	17868.8359	18878.7930	-2.4614	-8.2526
3	18037.9500	17884.6602	18899.8809	0.8498	-4.7784
4	19276.9800	17865.4453	18821.0625	7.3224	2.3651
5	19387.4000	17885.7383	18901.1016	7.7456	2.5083
6	18913.9100	18012.3262	18951.9570	4.7668	-0.2012
7	18635.4700	17980.1758	19012.4609	3.5164	-2.0230
8	18247.9600	18031.0371	19071.0977	1.1888	-4.5108
9	18028.7800	18072.1191	19062.9121	-0.2404	-5.7360
10	18083.1800	18103.5586	19105.6680	-0.1127	-5.6544
11	17870.0300	18160.4473	19305.6914	-1.6252	-8.0339
12	17707.3000	18194.4336	19738.9160	-2.7510	-11.4733
13	17963.8100	18215.6191	19767.1191	-1.4018	-10.0386
14	17615.1200	18218.8652	19780.9590	-3.4274	-12.2953
15	17534.0200	18236.2871	19736.0059	-4.0052	-12.5584
16	18576.2600	18239.8203	19615.9355	1.8111	-5.5968
17	19117.6400	18333.1582	19632.0273	4.1034	-2.6906
18	19653.5700	18525.3750	19629.5664	5.7404	0.1221
19	19297.3800	18749.0957	19639.7871	2.8412	-1.7744
20	20002.3000	18982.1211	19652.7383	5.1003	1.7476
21	20065.3600	19204.1094	19614.7402	4.2922	2.2458
22	20232.6700	19396.5176	19621.8672	4.1327	3.0189
23	20265.4900	19571.6328	19760.8652	3.4238	2.4901
AVERAGE	18628.105	18310.5179851	19317.6940104	1.5583	-3.9260

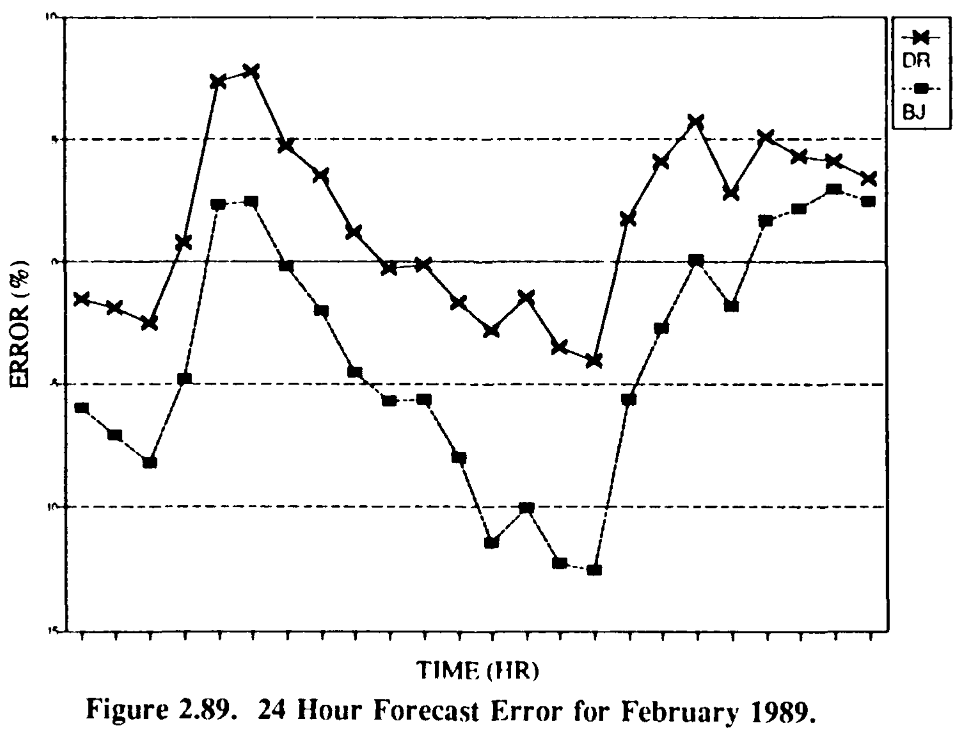

Figure 2.89. 24 Hour Forecast Error for February 1989.

Table 3.89

Measured and Model-Predicted Steam Flow Data for March 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	18912.0000	17424.2363	18320.1465	7.8668	3.1295
1	20155.2000	19296.7188	18517.4609	4.2594	8.1256
2	18490.1000	19026.1621	18731.4746	-2.8992	-1.3054
3	18594.5000	20508.8340	18820.1387	-10.2952	-1.2135
4	18265.2000	21295.0039	19062.5176	-16.5878	-4.3652
5	19013.4000	19272.5605	19128.0176	-1.3630	-0.6028
6	19628.3000	22250.4609	19046.6855	-13.3591	2.9631
7	16958.1000	21133.3730	19204.2813	-24.6211	-13.2455
8	17688.5000	16963.9414	19201.4766	4.0962	-8.5534
9	18161.9000	15289.3730	19558.3828	15.8162	-7.6891
10	17099.5000	15007.0596	19622.3203	12.2369	-14.7538
11	16570.4000	14237.0430	19564.5840	14.0815	-18.0695
12	16345.2000	13522.8926	19646.4258	17.2669	-20.1969
13	15432.6000	13457.0791	19712.5781	12.8010	-27.7334
14	14877.0000	13433.6064	19773.8262	9.7022	-32.9154
15	15520.0000	12976.5039	19838.4824	16.3885	-27.8253
16	15259.3000	12869.2227	19890.8027	15.6631	-30.3520
17	16361.9000	13435.6328	19949.8457	17.8846	-21.9287
18	17175.4000	14104.9883	20014.0703	17.8768	-16.5275
19	17241.7000	14619.7568	20061.6094	15.2070	-16.3552
20	17330.2000	15126.9814	20115.4238	12.7132	-16.0715
21	17788.5000	15530.2031	20145.9570	12.6953	-13.2527
22	17852.3000	16123.5225	20190.6230	9.6838	-13.0982
23	17496.8000	16526.1719	20239.7715	5.5475	-15.6770
AVERAGE	17425.7500	16392.9720	19514.8709	5.9267	-11.9887

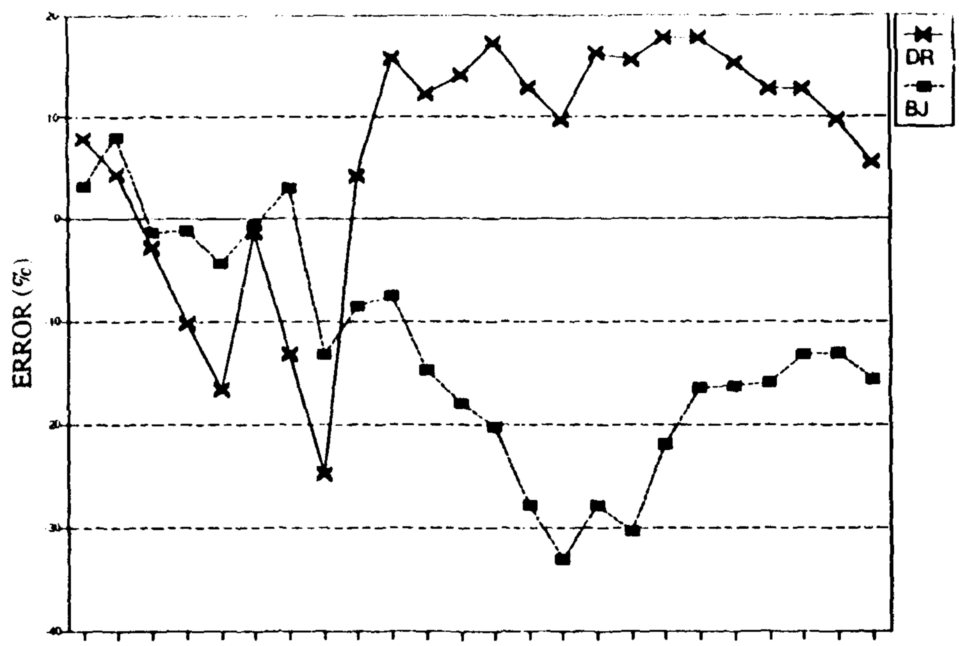

Figure 3.89. 24 Hour Forecast Error for March 1989.

Table 4.89

Measured and Model-Predicted Steam Flow Data for April 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	12337.5900	12805.0332	12461.0586	-3.7888	-1.0008
1	12275.7600	13173.0107	12647.9199	-7.3091	-3.0317
2	12715.3300	13601.2822	12823.8613	-6.9676	-0.8535
3	12690.4100	14026.8086	12989.5215	-10.5308	-2.3570
4	12946.8800	14380.3418	13145.5000	-11.0719	-1.5341
5	12504.0800	14820.9990	13292.3633	-18.5293	-6.3042
6	12890.7800	14904.9336	13430.6445	-15.6248	-4.1880
7	13256.5900	15072.6875	13560.8447	-13.6996	-2.2951
8	13436.5000	15076.6602	13683.4355	-12.2068	-1.8378
9	12762.3300	15075.3330	13798.8623	-18.1237	-8.1218
10	12373.1800	14825.3818	13907.5439	-19.8187	-12.4007
11	11905.7300	14587.3408	14009.8740	-22.5237	-17.6734
12	11761.4200	14316.0010	14106.2236	-21.7200	-19.9364
13	11896.3800	14082.2188	14196.9434	-18.3740	-19.3383
14	11756.5400	13845.6699	14282.3613	-17.7699	-21.4844
15	11971.9800	13644.5811	14362.7871	-13.9710	-19.9700
16	11995.4400	13527.2861	14438.5137	-12.7702	-20.3667
17	11815.7400	13428.7803	14509.8145	-13.6516	-22.8007
18	11946.1500	13394.8535	14576.9482	-12.1269	-22.0221
19	12764.3900	13370.8672	14640.1592	-4.7513	-14.6953
20	11491.3500	13413.9189	14699.6758	-16.7306	-27.9195
21	11701.4800	13457.6895	14755.7148	-15.0084	-26.1013
22	12396.6400	13531.1357	14808.4785	-9.1516	-19.4556
23	12434.8800	13634.9355	14858.1592	-9.6507	-19.4878
AVERAGE	12334.4813	13999.9063	13916.1337	-13.5022	-12.8230

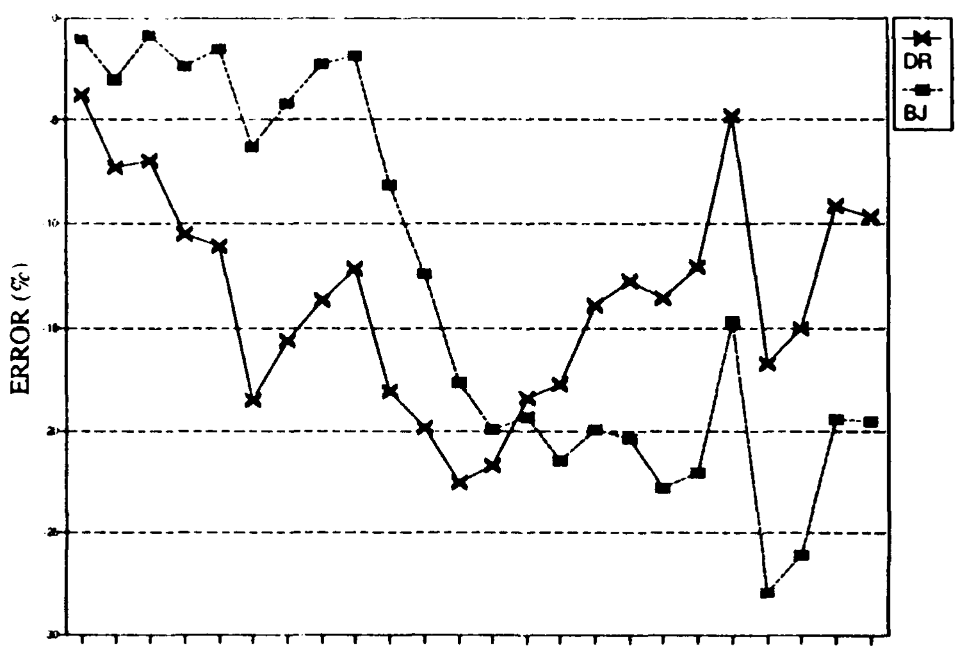

Figure 4.89. 24 Hour Forecast Error for April 1989.

Table 5.89

Measured and Model-Predicted Steam Flow Data for May 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	14876.2100	14909.7266	14861.3301	-0.2253	0.1000
1	14293.5500	15014.6445	14959.7920	-5.0449	-4.6611
2	14727.8700	14986.6221	14823.0557	-1.7569	-0.6463
3	14905.9300	15097.3770	14935.0889	-1.2844	-0.1956
4	15544.3400	15114.9443	14865.2949	2.7624	4.3684
5	15476.7300	14660.6855	14605.3008	5.2727	5.6306
6	13798.4800	14095.3223	14630.2139	-2.1513	-6.0277
7	13424.6600	13510.3545	14415.2705	-0.6383	-7.3790
8	13045.2200	13142.3027	14446.7676	-0.7442	-10.7438
9	12820.1400	12767.3623	14141.2256	0.4117	-10.3048
10	12549.8000	12753.9717	14269.1191	-1.6269	-13.7000
11	11961.8800	12508.9150	13747.8311	-4.5732	-14.9304
12	11630.4800	12344.2188	13724.7988	-6.1368	-18.0072
13	11728.5200	11991.1592	13410.1309	-2.2393	-14.3378
14	11894.3200	12110.7861	13632.9834	-1.8199	-14.6176
15	11225.2800	12054.3584	13533.7471	-7.3858	-20.5649
16	11587.5300	12027.5313	13439.5918	-3.7972	-15.9832
17	12007.7100	12298.4229	13753.9385	-2.4211	-14.5426
18	12684.3100	12473.7510	13772.7197	1.6600	-8.5808
19	12559.3700	12642.2715	13844.0273	-0.6601	-10.2287
20	12566.2300	12799.0400	13741.9014	-1.8527	-9.3558
21	12604.4800	13290.5459	13830.9238	-5.4430	-9.7302
22	12587.5900	13398.2881	13855.0566	-6.4405	-10.0692
23	12805.1300	13704.2109	14035.2773	-7.0213	-9.6067
AVERAGE	13054.4067	13320.7005	14136.4744	-2.0399	-8.2889

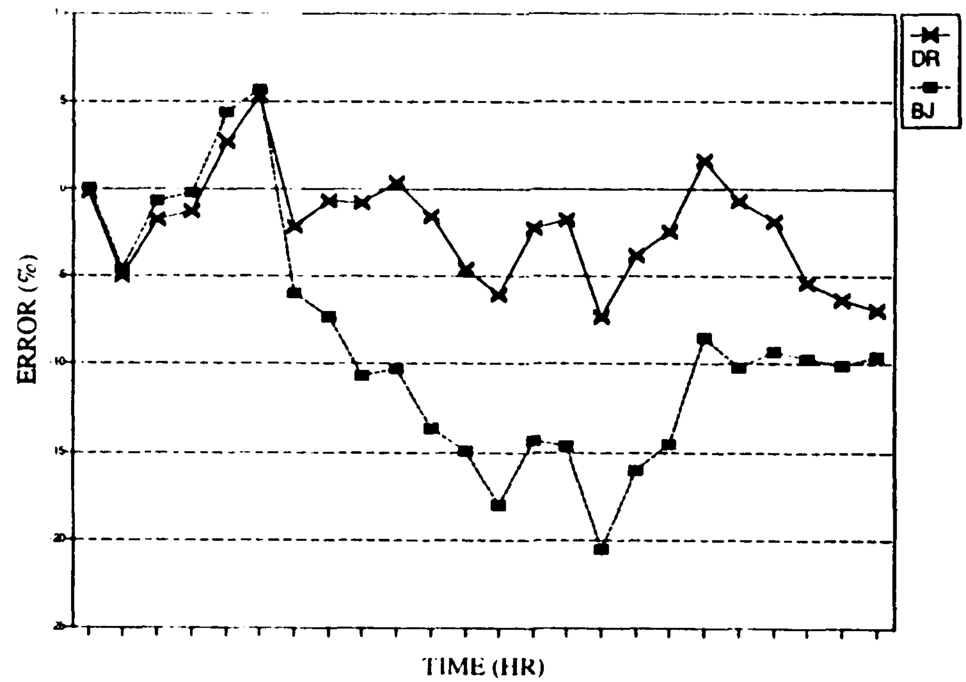

Figure 5.89. 24 Hour Forecast Error for May 1989.

Table 6.89

Measured and Model-Predicted Steam Flow Data for June 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	13934.4000	13205.2539	14218.3125	5.2327	-2.0375
1	13819.0800	13349.9629	14314.2480	3.3947	-3.5832
2	13982.3300	14365.7021	14399.6777	-2.7418	-2.9848
3	14011.2800	14948.5889	14475.7529	-6.6897	-3.3150
4	13987.2500	15207.3027	14543.4980	-8.7226	-3.9768
5	13852.4800	15571.2520	14603.8252	-12.4077	-5.4239
6	13929.0800	15741.6592	14657.5459	-13.0129	-5.2298
7	13791.7800	15387.8193	14705.3838	-11.5724	-6.6243
8	14269.4300	14190.8721	14747.9834	0.5505	-3.3537
9	13908.8000	14258.6123	14785.9180	-2.5150	-6.3062
10	12192.5300	14328.3857	14819.6992	-17.5177	-21.5474
11	14540.0000	14000.6514	14849.7813	3.7094	-2.1305
12	13988.0800	14164.9980	14876.5693	-1.2648	-6.3518
13	13555.2800	13848.8994	14900.4238	-2.1661	-9.9234
14	13565.1300	14452.5850	14921.6660	-6.5422	-10.0002
15	14365.9000	15322.2070	14940.5820	-6.6568	-4.0003
16	13557.8000	15513.2363	14957.4268	-14.4230	-10.3234
17	13566.1800	14453.4609	14972.4268	-6.5404	-10.3658
18	13529.2800	14306.7646	14985.7852	-5.7467	-10.7656
19	13470.7000	14258.8477	14997.6807	-5.8508	-11.3356
20	14544.0500	14331.7324	15008.2734	1.4598	-3.1918
21	13475.9800	14631.8662	15017.7061	-8.5774	-11.4405
22	13434.5800	14750.2900	15026.1055	-9.7935	-11.8465
23	13872.3300	14922.8945	15033.5859	-7.5731	-8.3710
AVERAGE	13797.6554	14563.0769	14781.6607	-5.5475	-7.1317

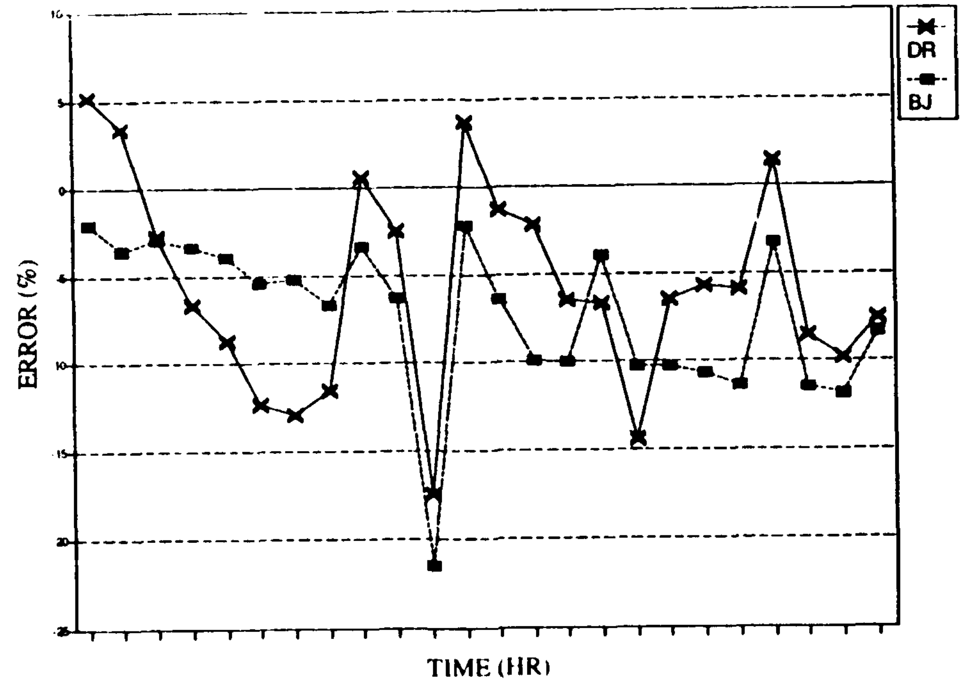

Figure 6.89. 24 Hour Forecast Error for June 1989.

Table 7.89

Measured and Model-Predicted Steam Flow Data for July 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	13149.6800	13533.2949	13628.6611	-2.9173	-3.6425
1	13164.5000	13545.5527	13628.6611	-2.8945	-3.5259
2	12750.3500	13578.2129	13628.6611	-6.4929	-6.8885
3	12871.1500	13583.0762	13628.6611	-5.5312	-5.8853
4	13162.3000	13582.6260	13628.6611	-3.1934	-3.5432
5	13829.8800	13595.0186	13628.6611	1.6982	1.4550
6	13666.1300	13593.2803	13628.6611	0.5331	0.2742
7	13608.1300	13547.3916	13628.6611	0.4463	-0.1509
8	15353.0000	13500.4668	13628.6611	12.0663	11.2313
9	14325.5000	13477.9775	13628.6611	5.9162	4.8643
10	15113.7000	13427.1680	13628.6611	11.1590	9.8258
11	14795.8800	13399.2549	13628.6611	9.4393	7.8888
12	14793.1800	13387.8213	13628.6611	9.5000	7.8720
13	11089.4000	13359.6289	13628.6611	-20.4721	-22.8981
14	9673.0300	13393.1445	13628.6611	-38.4586	-40.8934
15	18201.1800	13390.1270	13628.6611	26.4326	25.1221
16	18265.3000	13316.7725	13628.6611	27.0925	25.3850
17	18048.0800	13313.8555	13628.6611	26.2312	24.4869
18	17082.1300	13304.1631	13628.6611	22.1165	20.2169
19	17013.7800	13346.3057	13628.6611	21.5559	19.8963
20	16740.8300	13409.8301	13628.6611	19.8975	18.5903
21	16318.5300	13445.1963	13628.6611	17.6078	16.4835
22	17054.5300	13440.6387	13628.6611	21.1902	20.0877
23	15891.3500	13484.9736	13628.6611	15.1427	14.2385
AVERAGE	14831.7300	13456.4907	13628.6611	9.2723	8.1115

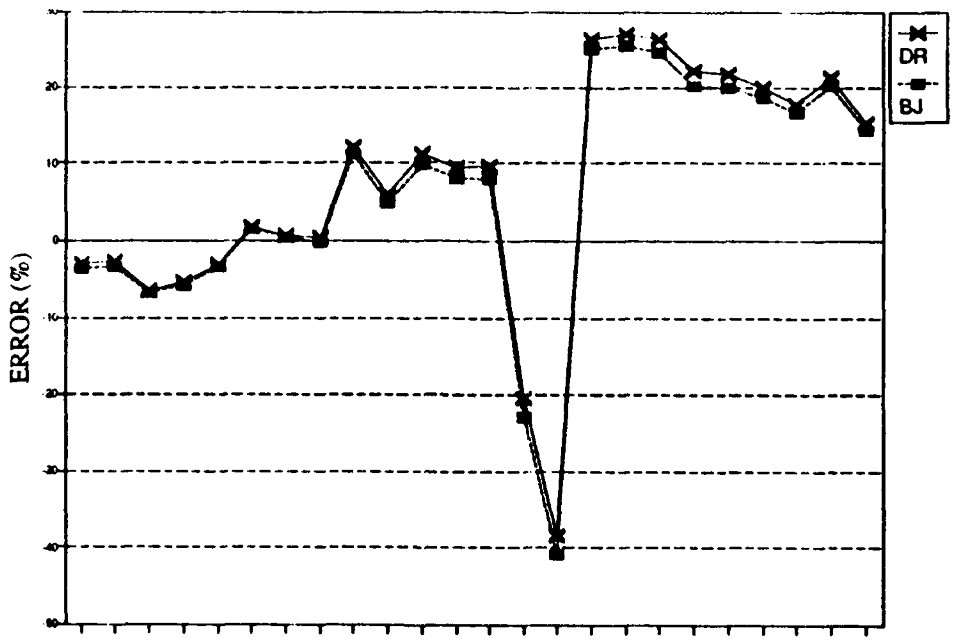

Figure 7.89. 24 Hour Forecast Error for July 1989.

Table 8.89

Measured and Model-Predicted Steam Flow Data for August 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	13714.7300	13419.8008	13564.4229	2.1505	1.0960
1	13082.9500	13163.5752	13493.9756	-0.6163	-3.1417
2	13566.3800	12954.2666	13428.1426	4.5120	1.0190
3	13020.2500	12691.1670	13366.2031	2.5275	-2.6570
4	13146.7800	12518.1289	13307.8613	4.7818	-1.2253
5	12347.2800	12403.9766	13252.8984	-0.4592	-7.3346
6	12318.2800	12279.0996	13201.1172	0.3181	-7.1669
7	12283.1300	12276.7324	13152.3330	0.0521	-7.0764
8	11809.5800	12683.8799	13106.3730	-7.4033	-10.9809
9	12601.4800	12898.4883	13063.0732	-2.3569	-3.6630
10	12899.8000	13006.3662	13022.2793	-0.8261	-0.9495
11	13122.2000	13264.2686	12983.8467	-1.0827	1.0543
12	13293.1500	13331.0654	12947.6387	-0.2852	2.5992
13	13698.1800	13394.8145	12913.5264	2.2146	5.7282
14	14120.5500	13358.9453	12881.3887	5.3936	8.7756
15	14255.8000	13275.7520	12851.1113	6.8747	9.8535
16	13963.9300	13272.7754	12822.5869	4.9496	8.1735
17	13802.3500	13295.1689	12795.7129	3.6746	7.2932
18	13568.3000	13164.5820	12770.3945	2.9754	5.8807
19	13462.6800	13004.4775	12746.5420	3.4035	5.3194
20	13392.8800	12906.4189	12724.0703	3.6322	4.9938
21	13118.2800	12858.0996	12702.8984	1.9833	3.1664
22	12909.0300	12829.2207	12682.9521	0.6182	1.7513
23	12930.9300	12857.3721	12664.1602	0.5689	2.0630
AVERAGE	13184.5375	12962.8518	13018.5629	1.6814	1.2589

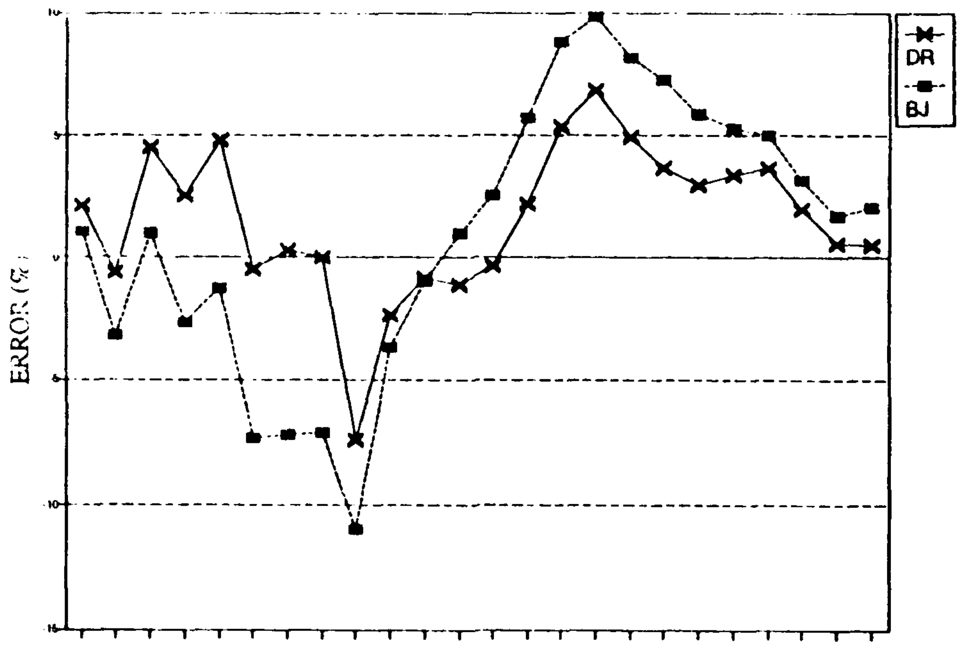

Figure 8.89. 24 Hour Forecast Error for August 1989.

Table 9.89a

Measured and Model-Predicted Steam Flow Data for September 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	9162.0000	9174.3027	9173.5205	-0.1343	-0.1257
1	9183.2500	9178.2559	9177.9453	0.0544	0.0578
2	9193.3000	9177.7070	9177.9453	0.1696	0.1670
3	9189.6300	9188.7285	9177.9453	0.0098	0.1272
4	9179.7300	9183.6074	9177.9453	-0.0422	0.0194
5	9174.2300	9184.0049	9177.9453	-0.1065	-0.0405
6	9168.2800	9183.5332	9177.9453	-0.1664	-0.1054
7	9212.0800	9181.5869	9177.9453	0.3310	0.3705
8	9275.4300	9181.7021	9177.9453	1.0105	1.0510
9	9197.8800	9181.1621	9177.9453	0.1818	0.2167
10	9185.5300	9183.0957	9177.9453	0.0265	0.0826
11	9189.1000	9183.3330	9177.9453	0.0628	0.1214
12	9173.5500	9183.2510	9177.9453	-0.1057	-0.0479
13	9165.0500	9183.5049	9177.9453	-0.2014	-0.1407
14	9163.8300	9183.2607	9177.9453	-0.2120	-0.1540
15	9178.8300	9183.1855	9177.9453	-0.0475	0.0096
16	9183.4000	9183.0830	9177.9453	0.0035	0.0594
17	9216.8500	9183.3252	9177.9453	0.3637	0.4221
18	9267.5300	9183.5146	9177.9453	0.9066	0.9667
19	9190.5500	9183.5879	9177.9453	0.0758	0.1371
20	9165.2800	9183.7324	9177.9453	-0.2013	-0.1382
21	9140.8500	9183.8057	9177.9453	-0.4699	-0.4058
22	9136.3800	9183.8438	9177.9453	-0.5195	-0.4549
23	9183.2500	9183.8730	9177.9453	-0.0068	0.0578
AVERAGE	9186.4913	9182.6245	9177.7609	0.0421	0.0950

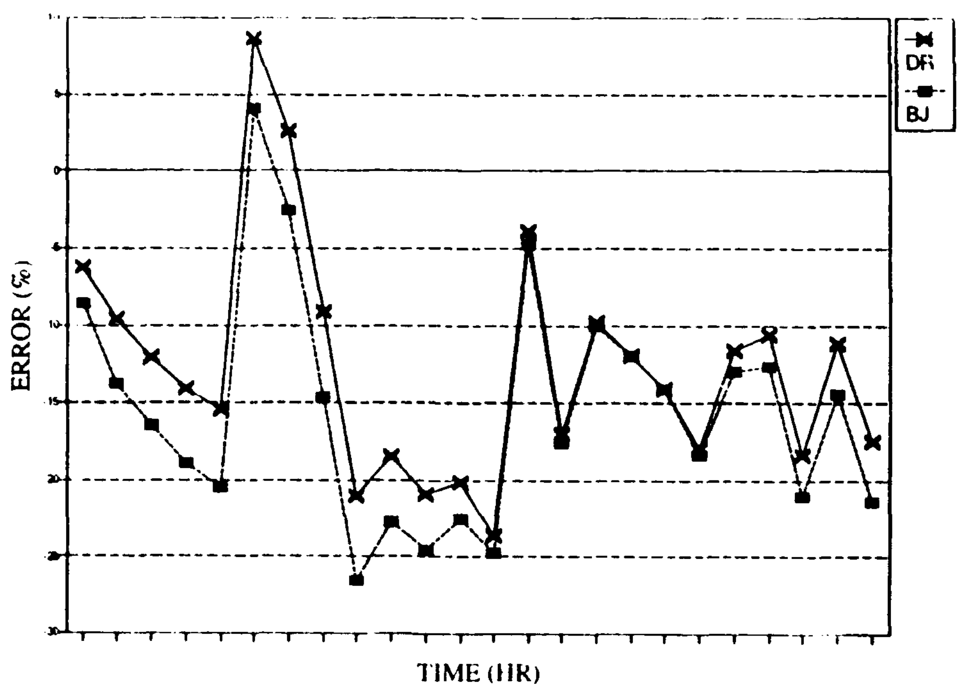

Figure 9.89a. 24 Hour Forecast Error for September 1989.

Table 9.89b

Measured and Model-Predicted Steam Flow Data for September 1989
Based on Cooling Degree Data

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	12619.6500	13589.6758	13245.8096	-7.6866	-4.9613
1	10983.4000	14207.4717	13798.1152	-29.3540	-25.6270
2	9870.7300	13710.0088	13516.8809	-38.8956	-36.9390
3	9996.2500	13268.0811	13355.4814	-32.7306	-33.6049
4	10414.8300	13193.1973	13467.3535	-26.6770	-29.3094
5	10148.4800	12865.8936	13135.9922	-26.7766	-29.4380
6	10407.0000	12752.6455	13221.1309	-22.5391	-27.0408
7	14843.8300	12667.0322	13256.5596	14.6647	10.6931
8	13893.9500	14090.9727	14642.2451	-1.4180	-5.3858
9	13784.7000	13061.1084	13185.8965	5.2492	4.3440
10	13559.3300	13049.5322	13331.8818	3.7598	1.6774
11	13738.9800	13143.9463	13295.5313	4.3310	3.2277
12	12341.8500	13240.0762	13284.5771	-7.2779	-7.6385
13	14809.3000	13284.7539	13294.7891	10.2945	10.2268
14	14444.5500	13112.4229	13299.8252	9.2224	7.9250
15	14407.5000	13363.7002	13477.0762	7.2448	6.4579
16	13796.5300	13434.5449	13515.6104	2.6237	2.0362
17	14169.6000	13308.5811	13457.9219	6.0765	5.0226
18	11971.1000	13222.6152	13442.0625	-10.4545	-12.2876
19	12650.2800	12978.3438	13219.5967	-2.5933	-4.5004
20	12427.2500	13112.3945	13384.9326	-5.5132	-7.7063
21	12626.9000	13095.1924	13392.2217	-3.7087	-6.0610
22	13002.9000	13070.0469	13373.3350	-0.5164	-2.8489
23	12486.5500	12853.3496	13204.3105	-2.9376	-5.7483
AVERAGE	12641.4767	13236.4828	13408.2974	-4.7068	-6.0659

REMARKS: The data in this table is based on the cooling degree hour data.

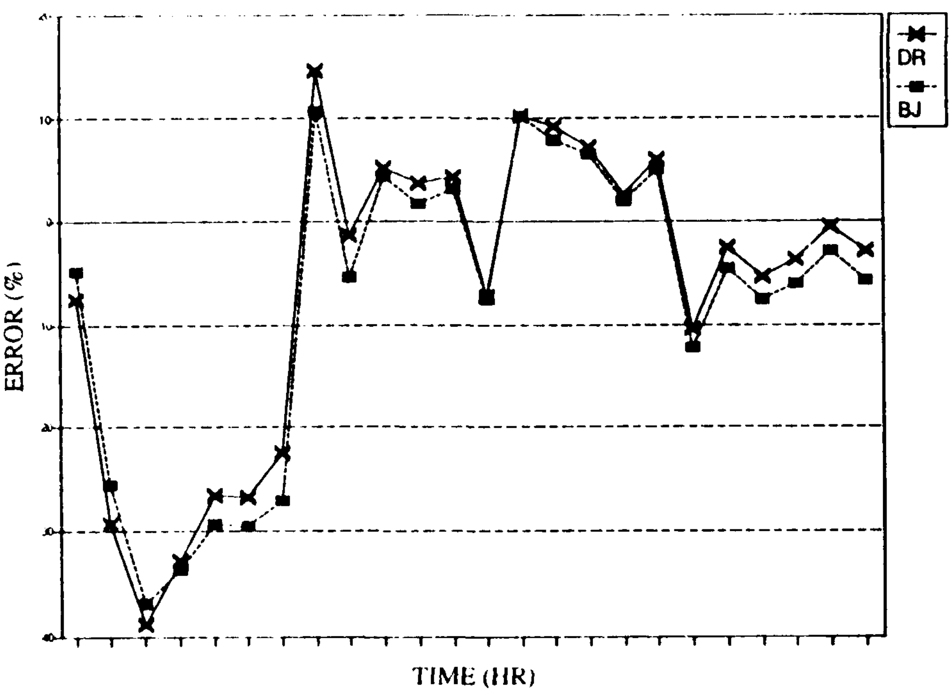

Figure 9.89b. 24 Hour Forecast Error for September 1989 Based on Cooling Degree Hour Data.

Table 10.89

Measured and Model-Predicted Steam Flow Data for October 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	22062.8300	20493.3242	20603.6660	7.1138	6.6137
1	22377.5500	20591.0645	20603.6660	7.9834	7.9271
2	22377.5000	20433.5059	20603.6660	8.6873	7.9269
3	21881.6000	20227.8691	20603.6660	7.5576	5.8402
4	21972.1000	20305.0996	20603.6660	7.5869	6.2281
5	21949.5500	20298.5918	20603.6660	7.5216	6.1317
6	22148.4000	20213.4707	20603.6660	8.7362	6.9745
7	22052.7300	20101.9473	20603.6660	8.8460	6.5709
8	21589.6300	19989.3809	20603.6660	7.4121	4.5668
9	22008.9000	19927.3457	20603.6660	9.4578	6.3848
10	21445.4800	19875.2012	20603.6660	7.3222	3.9254
11	22113.1000	19781.5000	20603.6660	10.5440	6.8260
12	22822.4800	19704.8906	20603.6660	13.6602	9.7221
13	24387.7500	19657.1250	20603.6660	19.3975	15.5163
14	22258.6800	19612.8945	20603.6660	11.8865	7.4354
15	21511.1300	19529.3516	20603.6660	9.2128	4.2186
16	20299.5300	19385.4453	20603.6660	4.5030	-1.4982
17	18846.2500	19174.1621	20603.6660	-1.7399	-9.3250
18	18522.6300	18893.1445	20603.6660	-2.0003	-11.2351
19	19475.4500	18610.6895	20603.6660	4.4403	-5.7930
20	19803.4800	18357.0664	20603.6660	7.3038	-4.0406
21	19140.0300	18131.8145	20603.6660	5.2676	-7.6470
22	18819.7300	17940.7793	20603.6660	4.6704	-9.4791
23	18930.2800	17772.7383	20603.6660	6.1148	-8.8397
AVERAGE	21199.8663	19512.0168	20603.6660	7.8201	2.8123

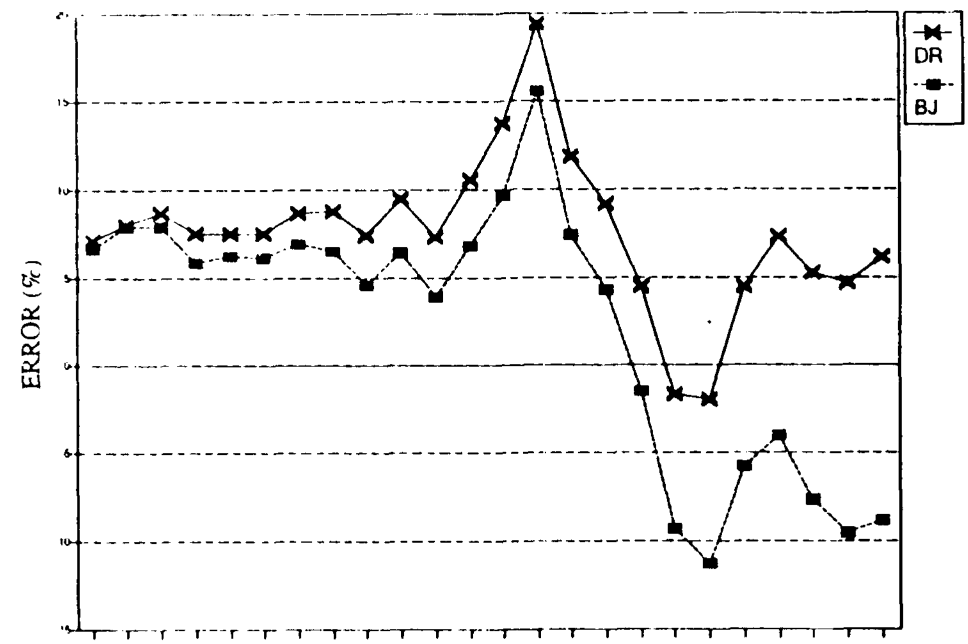

Figure 10.89. 24 Hour Forecast Error for October 1989.

Table 11.89

Measured and Model-Predicted Steam Flow Data for November 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	27782.8500	26408.8379	25947.3945	4.9455	6.6064
1	27955.7500	26826.4199	25914.5371	4.0397	7.3016
2	27497.6300	27347.0137	25857.0645	0.5477	5.9662
3	28052.5000	27667.9648	25829.9590	1.3708	7.9228
4	28373.3800	28075.8418	25834.6426	1.0487	8.9476
5	28578.0500	28349.1348	25787.9199	0.8010	9.7632
6	28968.0500	28497.3867	25935.6465	1.6248	10.4681
7	31290.6300	28538.2520	25972.4063	8.7962	16.9962
8	31627.5800	28610.2168	26031.6035	9.5403	17.6933
9	27758.2500	28378.1172	25971.7305	-2.2331	6.4360
10	29440.5500	28287.0098	25890.0801	3.9182	12.0598
11	28002.5300	28066.3594	25999.5469	-0.2279	7.1529
12	28546.1300	27878.7422	25975.4316	2.3379	9.0054
13	28533.5800	27827.3828	25972.9766	2.4750	8.9740
14	28226.3500	27645.9277	25968.6816	2.0563	7.9984
15	27093.8000	27623.5664	25966.6563	-1.9553	4.1602
16	25711.1000	27797.7930	25967.0059	-8.1159	-0.9953
17	28801.1500	27724.8008	25963.5137	3.7372	9.8525
18	29981.4800	28176.4785	25974.5547	6.0204	13.3647
19	29628.1800	28620.1230	25977.3027	3.4024	12.3223
20	29442.9300	28805.9277	25981.7266	2.1635	11.7556
21	29278.4300	28624.6172	25977.2520	2.2331	11.2751
22	26960.4000	28498.9043	25971.1504	-5.7065	3.6693
23	28171.1000	28652.5859	25979.3320	-1.7091	7.7802
AVERAGE	28570.9325	28038.7252	25943.6715	1.8628	9.1956

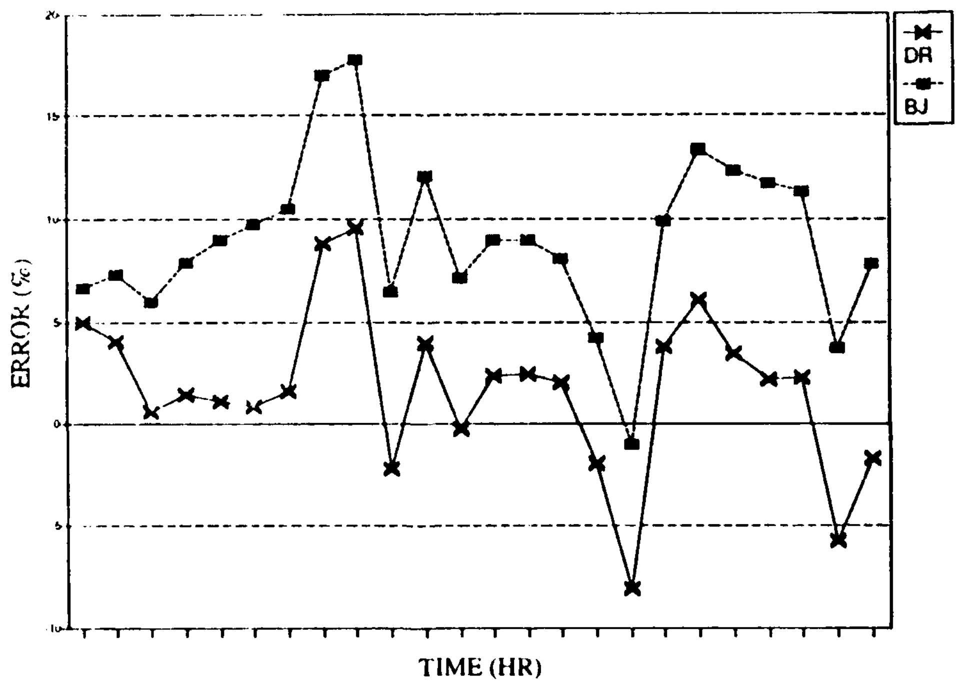

Figure 11.89. 24 Hour Forecast Error for November 1989.

Table 12.89

Measured and Model-Predicted Steam Flow Data for December 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	23809.9700	23314.3809	23965.3555	2.0814	-0.6526
1	23064.0000	23069.0879	24183.6777	-0.0221	-4.8547
2	23677.7500	23050.0918	24387.3281	2.6508	-2.9968
3	23603.6500	22892.3379	24557.4961	3.0136	-4.0411
4	23818.3500	22927.1836	24720.4219	3.7415	-3.7873
5	23643.7800	22976.5859	24868.4863	2.8219	-5.1798
6	23747.1800	22938.1445	24997.2754	3.4069	-5.2642
7	23891.2500	22980.6719	25099.5391	3.8113	-5.0575
8	24138.4700	23028.0332	25201.6738	4.6003	-4.4046
9	23943.9200	22999.0059	25292.7969	3.9464	-5.6335
10	24058.9500	23006.5078	25366.6973	4.3744	-5.4356
11	23987.4500	22929.9414	25443.4707	4.4086	-6.0699
12	23674.7800	22840.7539	25514.0527	3.5228	-7.7689
13	24074.0000	22777.9922	25577.2598	5.3834	-6.2443
14	23861.1700	22739.2832	25638.8438	4.7017	-7.4501
15	23806.7500	22728.7949	25686.3887	4.5279	-7.8954
16	23591.8800	22737.1523	25735.4434	3.6230	-9.0860
17	23916.6300	22750.5215	25780.6699	4.8757	-7.7939
18	23795.4200	22785.9199	25818.7793	4.2424	-8.5031
19	23799.6000	22801.3926	25844.7852	4.1942	-8.5934
20	23842.8500	22834.6172	25874.5781	4.2287	-8.5213
21	24358.8000	22879.8789	25901.0215	6.0714	-6.3313
22	23982.5500	23060.1328	25919.9121	3.8462	-8.0782
23	24005.8000	23277.9473	25943.3652	3.0320	-8.0712
AVERAGE	23837.2896	22930.2650	25304.9716	3.8051	-6.1571

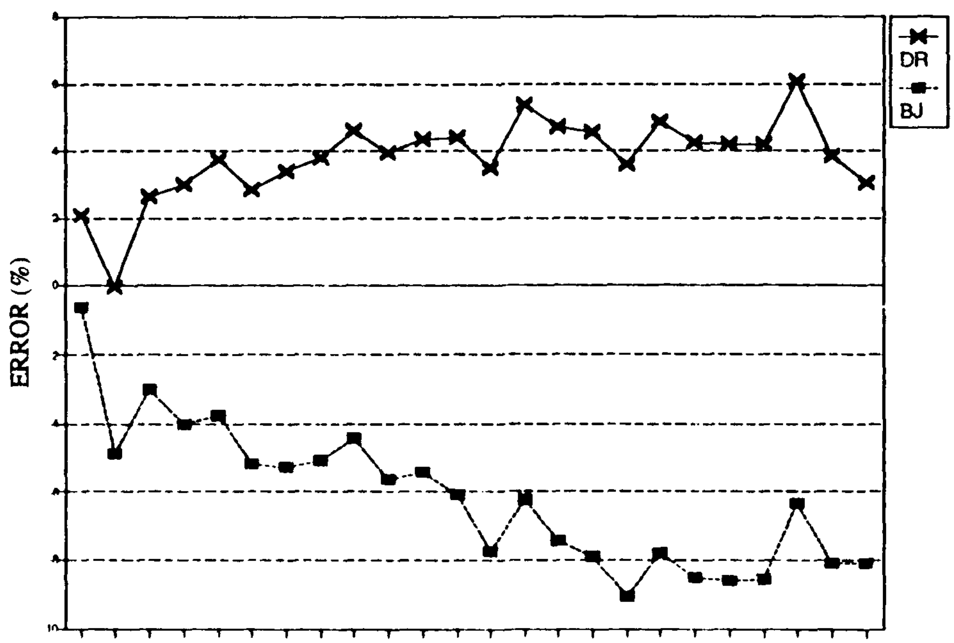

Figure 12.89. 24 Hour Forecast Error for December 1989.

Table 1.90

Measured and Model-Predicted Steam Flow Data for January 1990

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	19302.1500	19277.0215	19140.5586	0.1302	0.8372
1	19468.4000	19521.5078	19152.6250	-0.2728	1.6220
2	19631.3500	19861.5000	19163.2305	-1.1724	2.3846
3	19850.9000	20063.7852	19172.5527	-1.0724	3.4172
4	20544.3500	20108.0332	19180.7461	2.1238	6.6374
5	21390.9500	20291.6875	19187.9492	5.1389	10.2988
6	20636.6500	20366.5469	19194.2793	1.3089	6.9894
7	20218.3000	20526.9844	19199.8438	-1.5268	5.0373
8	19755.2500	20410.7695	19204.7344	-3.3182	2.7867
9	18646.7000	20099.5313	19209.0332	-7.7914	-3.0157
10	18099.3500	19625.7383	19212.8125	-8.4334	-6.1519
11	17659.5000	19217.1836	19216.1328	-8.8207	-8.8147
12	17217.1300	18801.5762	19219.0527	-9.2027	-11.6275
13	16546.0200	18569.3066	19221.6191	-12.2282	-16.1707
14	16429.0800	18324.5000	19223.8750	-11.5370	-17.0113
15	16716.8500	18195.1289	19225.8574	-8.8430	-15.0089
16	17527.3300	18350.3125	19227.5996	-4.6954	-9.7007
17	17935.0500	18655.2012	19229.1309	-4.0153	-7.2154
18	17840.9700	18787.4414	19230.4766	-5.3050	-7.7883
19	17907.7800	18889.1523	19231.6602	-5.4801	-7.3928
20	17917.7000	18870.9160	19232.6992	-5.3200	-7.3391
21	17406.6300	18499.8379	19233.6133	-6.2804	-10.4959
22	18003.7000	18660.9063	19234.4160	-3.6504	-6.8359
23	17709.0000	18754.7500	19235.1230	-5.9052	-8.6178
AVERAGE	18515.0454	19280.3883	19207.4842	-4.1336	-3.7399

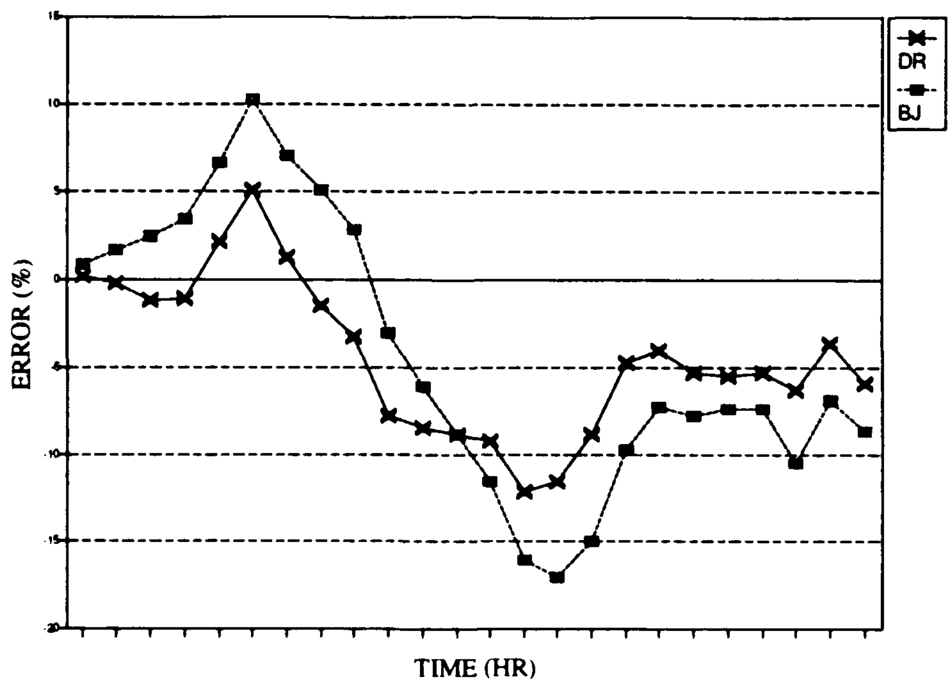

Figure 1.90. 24 Hour Forecast Error for January 1990.

Table 2.90

Measured and Model-Predicted Steam Flow Data for February 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	23794.3000	24335.8750	24308.1504	-2.2761	-2.1596
1	24192.9200	24238.6914	24051.9121	-0.1892	0.5828
2	24170.0300	24015.6191	23812.4160	0.6389	1.4796
3	23116.4700	23318.1230	23695.3574	-0.8723	-2.5042
4	23458.2500	23075.4043	24284.6680	1.6320	-3.5229
5	22943.1000	22626.1328	24190.0449	1.3815	-5.4349
6	21121.4500	21617.3633	23821.8984	-2.3479	-12.7853
7	21312.7500	21331.8984	23671.1816	-0.0898	-11.0658
8	21025.5000	21045.4688	23577.8027	-0.0950	-12.1391
9	20931.0300	20731.6543	23637.6387	0.9525	-12.9311
10	20586.4500	20463.0176	23857.9609	0.5996	-15.8916
11	20571.7500	20573.2520	24035.0762	-0.0073	-16.8354
12	20974.0500	20876.2383	24103.6270	0.4663	-14.9212
13	21043.3500	20997.6387	24194.4102	0.2172	-14.9741
14	20932.5500	21125.4121	24206.4395	-0.9214	-15.6402
15	21313.8800	21328.1465	24212.0254	-0.0669	-13.5975
16	20972.1000	21423.3047	24150.1973	-2.1515	-15.1539
17	21696.9500	21544.8789	24234.1367	0.7009	-11.6937
18	21117.4000	21729.3574	24200.6484	-2.8979	-14.6005
19	21883.0500	21946.1641	24251.4746	-0.2884	-10.8231
20	21865.3500	21999.0879	24137.5879	-0.6116	-10.3920
21	21983.7500	22266.2520	24249.5020	-1.2850	-10.3065
22	22168.7500	22431.4160	24181.7129	-1.1848	-9.0802
23	22522.4200	22498.2773	24256.3281	0.1072	-7.6986
AVERAGE	21904.0667	21980.7781	24055.0916	-0.3502	-9.8202

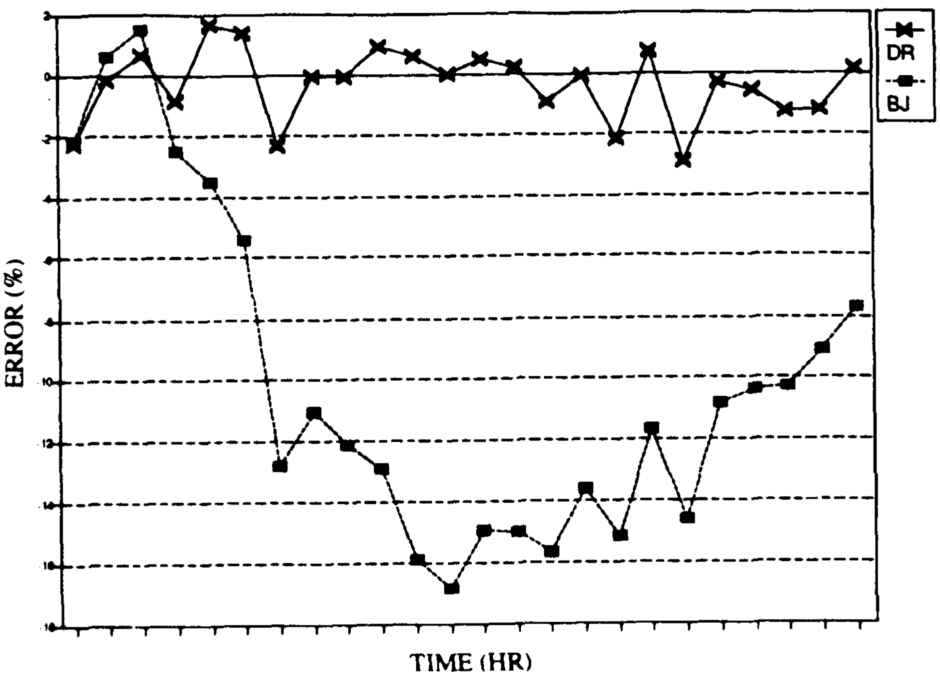

Figure 2.90. 24 Hour Forecast Error for February 1989.

Table 3.90

Measured and Model-Predicted Steam Flow Data for March 1989

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	18058.0500	16422.5410	18877.1777	9.0570	-4.5361
1	16680.3000	13410.4492	19134.9121	19.6031	-14.7156
2	16292.1000	12460.1875	19352.2598	23.5201	-18.7831
3	15830.2700	12708.6611	19535.5469	19.7192	-23.4063
4	16199.7000	12178.4307	19690.1133	24.8231	-21.5462
5	16767.5800	12921.9941	19820.4590	22.9347	-18.2070
6	16802.1500	13330.8311	19930.3789	20.6600	-18.6180
7	17186.3800	14026.7266	20023.0742	18.3846	-16.5055
8	18662.3300	16778.9375	20101.2422	10.0919	-7.7102
9	18967.1800	18402.5625	20167.1621	2.9768	-6.3266
10	19207.6300	19282.5840	20222.7520	-0.3902	-5.2850
11	19472.1500	19692.0332	20269.6309	-1.1292	-4.0955
12	19203.7500	20056.4082	20309.1641	-4.4401	-5.7562
13	19692.3500	20335.9102	20342.5020	-3.2681	-3.3015
14	19941.7000	20673.3945	20370.6152	-3.6692	-2.1508
15	19814.2800	20770.6270	20394.3242	-4.8266	-2.9274
16	20214.7300	20892.2539	20414.3164	-3.3516	-0.9873
17	20609.3500	20883.0859	20431.1758	-1.3282	0.8645
18	21829.0500	20962.1680	20445.3945	3.9712	6.3386
19	20937.4700	21080.8105	20457.3848	-0.6846	2.2929
20	20737.5000	21150.7793	20467.4961	-1.9929	1.3020
21	20500.4700	21074.7148	20476.0234	-2.8011	0.1192
22	20466.2000	20953.0156	20483.2129	-2.3786	-0.0831
23	20182.7000	20694.4063	20489.2773	-2.5354	-1.5190
AVERAGE	18927.3071	17964.3130	20091.8998	5.0879	-6.1530

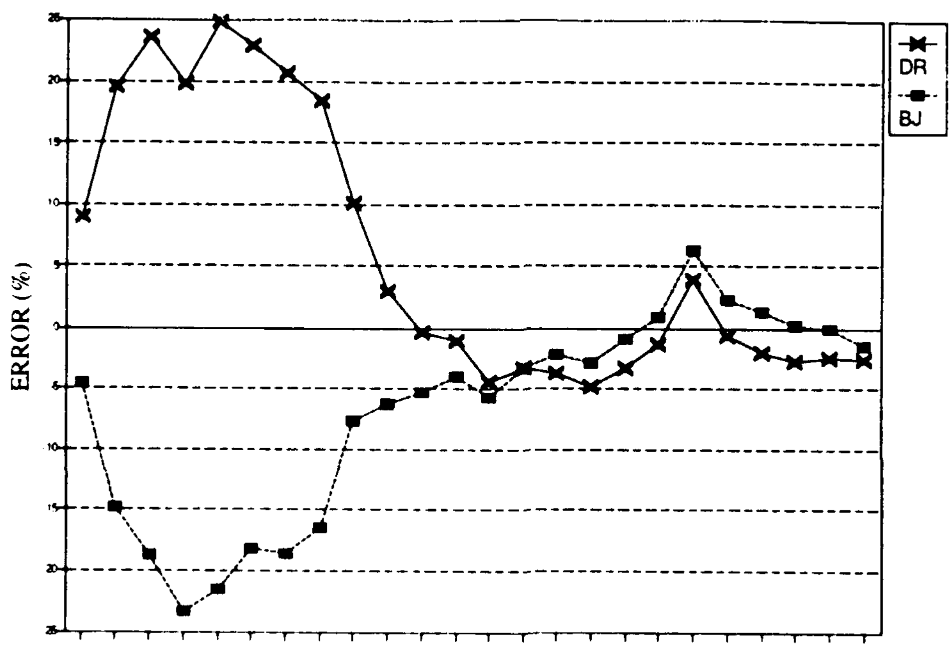

Figure 3.90. 24 Hour Forecast Error for March 1989.

Table 4.90

Measured and Model-Predicted Steam Flow Data for April 1990

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	11033.9700	10995.7021	11106.7119	0.3468	-0.6593
1	10970.2300	11346.0469	11097.2803	-3.4258	-1.1581
2	10899.8000	12264.2041	11101.0840	-12.5177	-1.8467
3	10734.1700	12100.5752	11099.5498	-12.7295	-3.4039
4	10687.2500	11161.5352	11100.1689	-4.4379	-3.8637
5	10687.4500	10573.1514	11099.9189	1.0695	-3.8594
6	10680.3500	10497.0078	11100.0195	1.7166	-3.9294
7	10652.3800	10622.7949	11099.9785	0.2777	-4.2019
8	10733.3000	10632.7959	11099.9951	0.9364	-3.4164
9	10752.2700	10607.2793	11099.9883	1.3485	-3.2339
10	10762.9500	10899.3438	11099.9912	-1.2673	-3.1315
11	10981.8800	11205.3516	11099.9902	-2.0349	-1.0755
12	10997.0000	11563.2783	11099.9902	-5.1494	-0.9365
13	10964.9200	11830.2178	11099.9902	-7.8915	-1.2318
14	10987.7300	11870.9277	11099.9902	-8.0380	-1.0217
15	10968.9200	11807.4844	11099.9902	-7.6449	-1.1949
16	10938.5000	12209.3174	11099.9902	-11.6178	-1.4763
17	10909.8000	12068.9609	11099.9902	-10.6250	-1.7433
18	10958.7500	11735.0137	11099.9902	-7.0835	-1.2888
19	10651.6300	10730.3955	11099.9902	-0.7395	-4.2093
20	10626.7500	10850.4551	11099.9902	-2.1051	-4.4533
21	10735.8800	10972.7441	11099.9902	-2.2063	-3.3915
22	10950.7500	11424.1211	11099.9902	-4.3227	-1.3628
23	10905.5000	11715.0020	11099.9902	-7.4229	-1.7834
AVERAGE	10840.5054	11320.1544	11100.1900	-4.4246	-2.3955

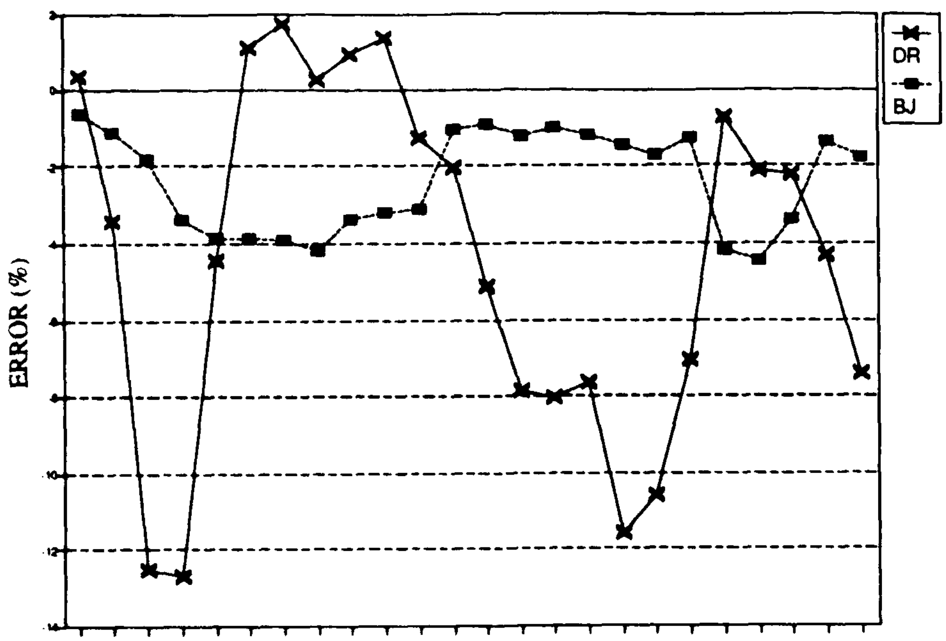

Figure 4.90. 24 Hour Forecast Error for April 1990.

Table 5.90

Measured and Model-Predicted Steam Flow Data for May 1990

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	14442.4200	14024.0137	13813.5293	2.8971	4.3545
1	14456.0200	13676.4541	13311.9424	5.3927	7.9142
2	14339.9000	13394.6523	12927.1875	6.5917	9.8516
3	14346.9200	13196.5127	12646.8193	8.0185	11.8499
4	14136.0500	13078.0039	12445.8418	7.4847	11.9567
5	14196.9000	13000.9346	12302.5615	8.4241	13.3433
6	14100.7000	12977.5439	12200.6045	7.9653	13.4752
7	14020.0200	12980.3262	12128.0986	7.4158	13.4944
8	13949.8800	13030.5059	12076.5479	6.5906	13.4290
9	13932.9700	13063.4121	12039.8984	6.2410	13.5870
10	13977.5000	13061.4180	12013.8438	6.5540	14.0487
11	13891.2800	13028.5908	11995.3213	6.2103	13.6486
12	13810.6500	12975.4268	11982.1533	6.0477	13.2398
13	13832.7700	12916.8789	11972.7920	6.6212	13.4462
14	13762.9800	12856.3320	11966.1367	6.5876	13.0556
15	13724.7000	12801.9395	11961.4053	6.7234	12.8476
16	13621.9800	12748.7588	11958.0420	6.4104	12.2151
17	13656.7000	12704.0156	11955.6514	6.9759	12.4558
18	13679.9000	12668.4258	11953.9521	7.3939	12.6167
19	13628.3200	12638.8564	11952.7441	7.2603	12.2948
20	14059.1300	12611.3057	11951.8848	10.2981	14.9884
21	14632.2500	12583.5400	11951.2734	14.0013	18.3224
22	13860.4800	12554.4199	11950.8389	9.4229	13.7776
23	14458.9200	12517.5918	11950.5303	13.4265	17.3484
AVERAGE	14021.6392	12962.0775	12225.4000	7.5566	12.8105

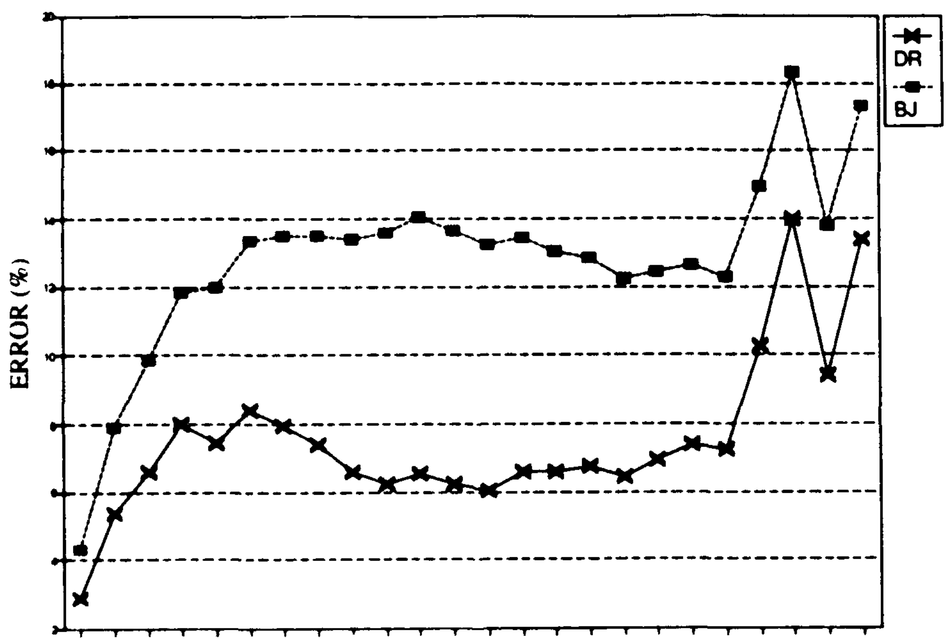

Figure 5.90. 24 Hour Forecast Error for May 1990.

Table 8.90

Measured and Model-Predicted Steam Flow Data for August 1990

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	8984.3500	8935.5869	9089.7559	0.5428	-1.1732
1	8971.0500	8887.2598	9203.9395	0.9340	-2.5960
2	8973.8300	8813.2949	9312.5391	1.7889	-3.7744
3	8986.5800	8774.4072	9407.7949	2.3610	-4.6872
4	8989.1000	8784.3018	9491.3066	2.2783	-5.5868
5	9010.1700	8793.0127	9561.3184	2.4101	-6.1170
6	9078.1700	8847.5967	9652.1924	2.5399	-6.3231
7	9029.2500	8946.3213	9675.6992	0.9184	-7.1595
8	8998.7000	9059.1191	9702.9678	-0.6714	-7.8263
9	8997.6300	9168.1748	9727.2002	-1.8954	-8.1085
10	9013.1000	9287.0166	9750.8604	-3.0391	-8.1854
11	8998.2200	9407.3516	9767.9121	-4.5468	-8.5538
12	8981.6300	9481.4443	9769.1309	-5.5649	-8.7679
13	8972.4000	9509.1914	9776.3818	-5.9827	-8.9606
14	8964.7300	9470.6719	9781.8066	-5.6437	-9.1143
15	8971.0500	9435.8252	9781.1768	-5.1808	-9.0305
16	8991.6500	9399.5967	9780.8477	-4.5370	-8.7770
17	8991.6000	9334.7725	9780.4053	-3.8166	-8.7727
18	8995.1700	9262.5137	9778.8242	-2.9721	-8.7119
19	8991.9000	9170.8145	9784.9502	-1.9897	-8.8196
20	8985.3800	9053.3721	9794.5664	-0.7567	-9.0056
21	8994.6500	8787.7490	9801.1895	2.3003	-8.9669
22	9006.3000	8715.8799	9794.6973	3.2246	-8.7538
23	9009.5500	8745.0010	9785.2354	2.9363	-8.6096
AVERAGE	8995.2567	9086.2615	9656.3624	-1.0117	-7.3495

* The hourly steam output forecasted here is based on the cooling degree hour.

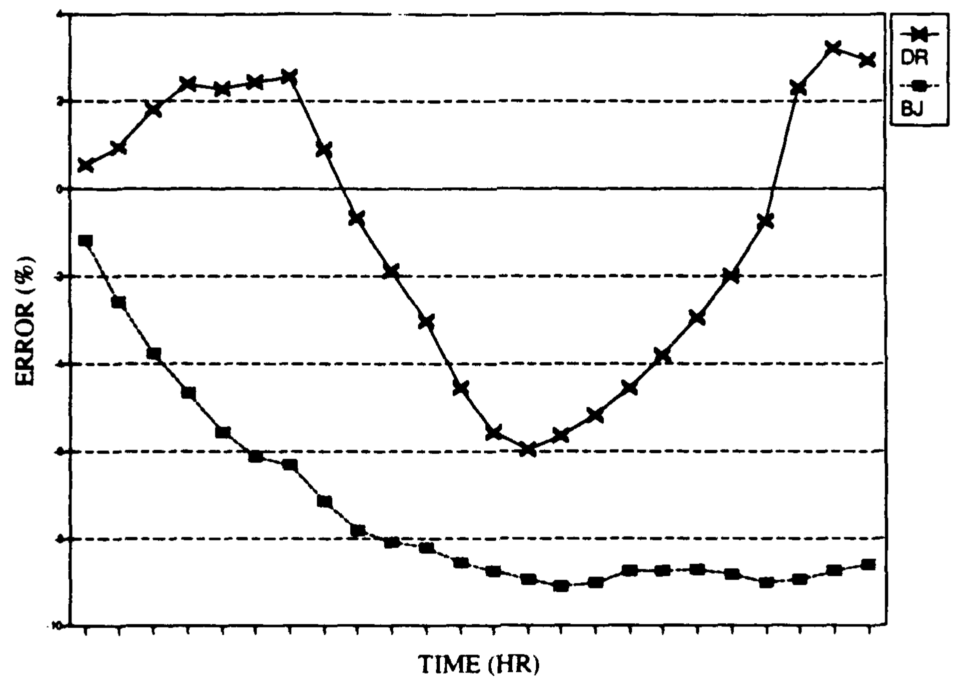

Figure 8.90. 24 Hour Forecast Error for August 1990.

Table 9.90a

Measured and Model-Predicted Steam Flow Data for September 1990

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	9162.0000	9174.3027	9173.5205	-0.1343	-0.1257
1	9183.2500	9178.2559	9177.9453	0.0544	0.0578
2	9193.3000	9177.7070	9177.9453	0.1696	0.1670
3	9189.6300	9188.7285	9177.9453	0.0098	0.1272
4	9179.7300	9183.6074	9177.9453	-0.0422	0.0194
5	9174.2300	9184.0049	9177.9453	-0.1065	-0.0405
6	9168.2800	9183.5332	9177.9453	-0.1664	-0.1054
7	9212.0800	9181.5869	9177.9453	0.3310	0.3705
8	9275.4300	9181.7021	9177.9453	1.0105	1.0510
9	9197.8800	9181.1621	9177.9453	0.1818	0.2167
10	9185.5300	9183.0957	9177.9453	0.0265	0.0826
11	9189.1000	9183.3330	9177.9453	0.0628	0.1214
12	9173.5500	9183.2510	9177.9453	-0.1057	-0.0479
13	9165.0500	9183.5049	9177.9453	-0.2014	-0.1407
14	9163.8300	9183.2607	9177.9453	-0.2120	-0.1540
15	9178.8300	9183.1855	9177.9453	-0.0475	0.0096
16	9183.4000	9183.0830	9177.9453	0.0035	0.0594
17	9216.8500	9183.3252	9177.9453	0.3637	0.4221
18	9267.5300	9183.5146	9177.9453	0.9066	0.9667
19	9190.5500	9183.5879	9177.9453	0.0758	0.1371
20	9165.2800	9183.7324	9177.9453	-0.2013	-0.1382
21	9140.8500	9183.8057	9177.9453	-0.4699	-0.4058
22	9136.3800	9183.8438	9177.9453	-0.5195	-0.4549
23	9183.2500	9183.8730	9177.9453	-0.0068	0.0578
AVERAGE	9186.4913	9182.6245	9177.7609	0.0421	0.0950

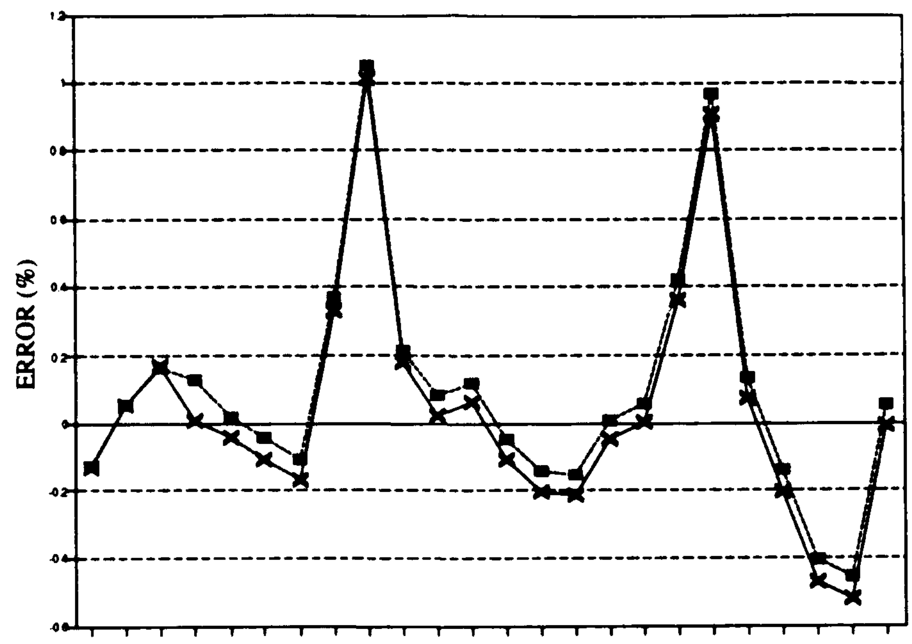

Figure 9.90a. 24 Hour Forecast Error for September 1990.

Table 9.90b

Measured and Model-Predicted Steam Flow Data for September 1990 Based on Cooling Degree Hours

HOUR	MEASURE (lbs/hr)	DR (lbs/hr)	BJ (lbs/hr)	DR ERR (%)	BJ ERR (%)
0	9166.9000	9170.0469	9166.1279	-0.0343	0.0084
1	9172.2300	9164.3701	9160.0762	0.0857	0.1325
2	9179.6800	9160.6016	9152.7783	0.2078	0.2931
3	9185.5300	9171.0088	9176.1826	0.1581	0.1018
4	9183.7300	9169.9902	9168.8271	0.1496	0.1623
5	9188.5000	9169.9238	9171.8252	0.2022	0.1815
6	9182.9500	9168.8047	9172.4434	0.1540	0.1144
7	9201.6500	9166.7422	9168.9404	0.3794	0.3555
8	9177.9300	9160.6201	9154.9365	0.1886	0.2505
9	9179.9800	9154.8291	9142.4717	0.2740	0.4086
10	9186.7000	9148.9678	9129.0557	0.4107	0.6275
11	9185.2800	9145.0635	9121.5850	0.4378	0.6934
12	9129.8000	9144.3779	9123.0928	-0.1597	0.0735
13	9146.9300	9144.7383	9126.1318	0.0240	0.2274
14	9160.7300	9143.3359	9123.8867	0.1899	0.4022
15	9154.6500	9142.6865	9124.0908	0.1307	0.3338
16	9158.5500	9142.5449	9124.9727	0.1748	0.3666
17	9157.4300	9140.7070	9121.0195	0.1826	0.3976
18	9139.9800	9136.9932	9113.0537	0.0327	0.2946
19	9151.4800	9134.7881	9110.2275	0.1824	0.4508
20	9146.8800	9133.8584	9110.2754	0.1424	0.4002
21	9176.8800	9132.9512	9109.7715	0.4787	0.7313
22	9150.5000	9129.9873	9103.6563	0.2242	0.5119
23	9140.3300	9127.9941	9100.9434	0.1350	0.4309
AVERAGE	9166.8833	9150.2472	9136.5155	0.1815	0.3313

* The hourly steam output forecasted here is based on the cooling degree hour.

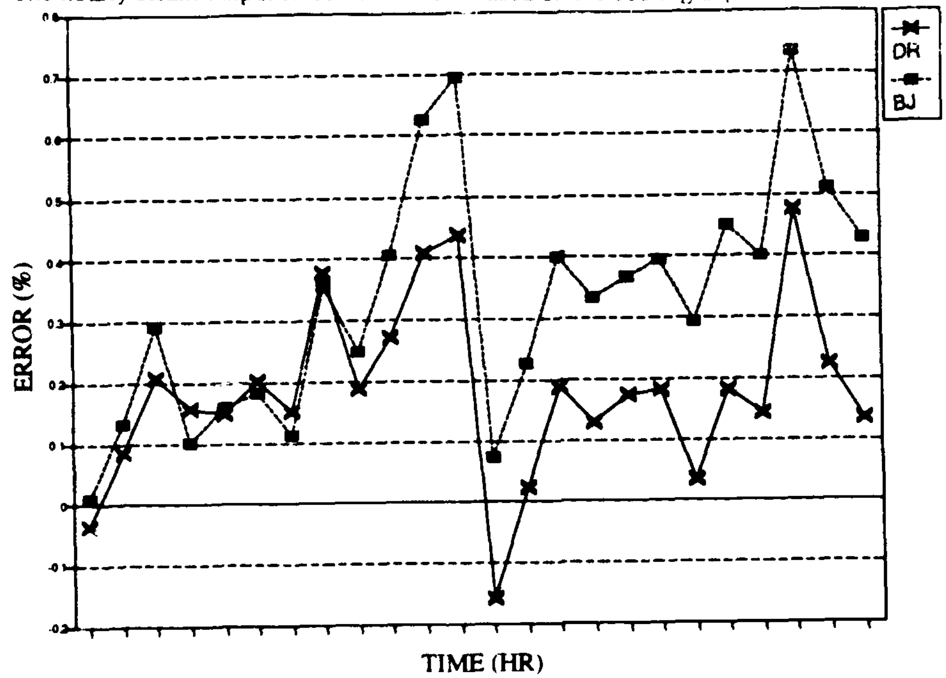

Figure 9.90b. 24 Hour Forecast Error for September 1990 Based on Cooling Degree Hours.

9 CONCLUSIONS AND RECOMMENDATIONS

Phase 1 of this study showed that hourly steam flow data can be represented as a Box-Jenkins transfer function model using lagged temperature data as input. The standard tests of goodness of fit indicate that the models specified are in excellent agreement with the historical data. In addition, when the data are free of aberration, the 1 hour ahead prediction error was about 4 percent. Since the model based on temperature lagged 2 hours has about the same predictive error as the model with no lag, temperature forecasts are not needed to forecast steam demand. These initial results are quite encouraging and indicate that accurate forecasts up to several hours ahead can likely be made using such models.

Phase 2 of this study showed that both the Box-Jenkins and dynamic regression models did an adequate job for 24 hour forecasts. The best results were obtained using the dynamic regression method with actual ambient temperatures. Twenty-four hour forecasting results obtained from Box-Jenkins univariate models appeared slightly less reliable; temperature information, however, was not needed for model building and forecasting.

It is recommended that Box-Jenkins models be considered prime candidates for load forecasting: their mathematics are simpler than those for dynamic regression models, because temperature data are not required. Nevertheless, weather information should also be taken into account in case of a significant variation in ambient temperature within the forecast period.

It is recommended that the feasibility of completely automating the identification of the prediction formula should be studied for field implementation of multiboiler load allocation.

If, instead of complete automation, it is preferred that an analyst be constantly involved with forecast model identification and use, then it is recommended that use of the software packages mentioned in Chapter 4 should be considered. They are user-friendly, and one has an expert system to guide the analyst during model identification.

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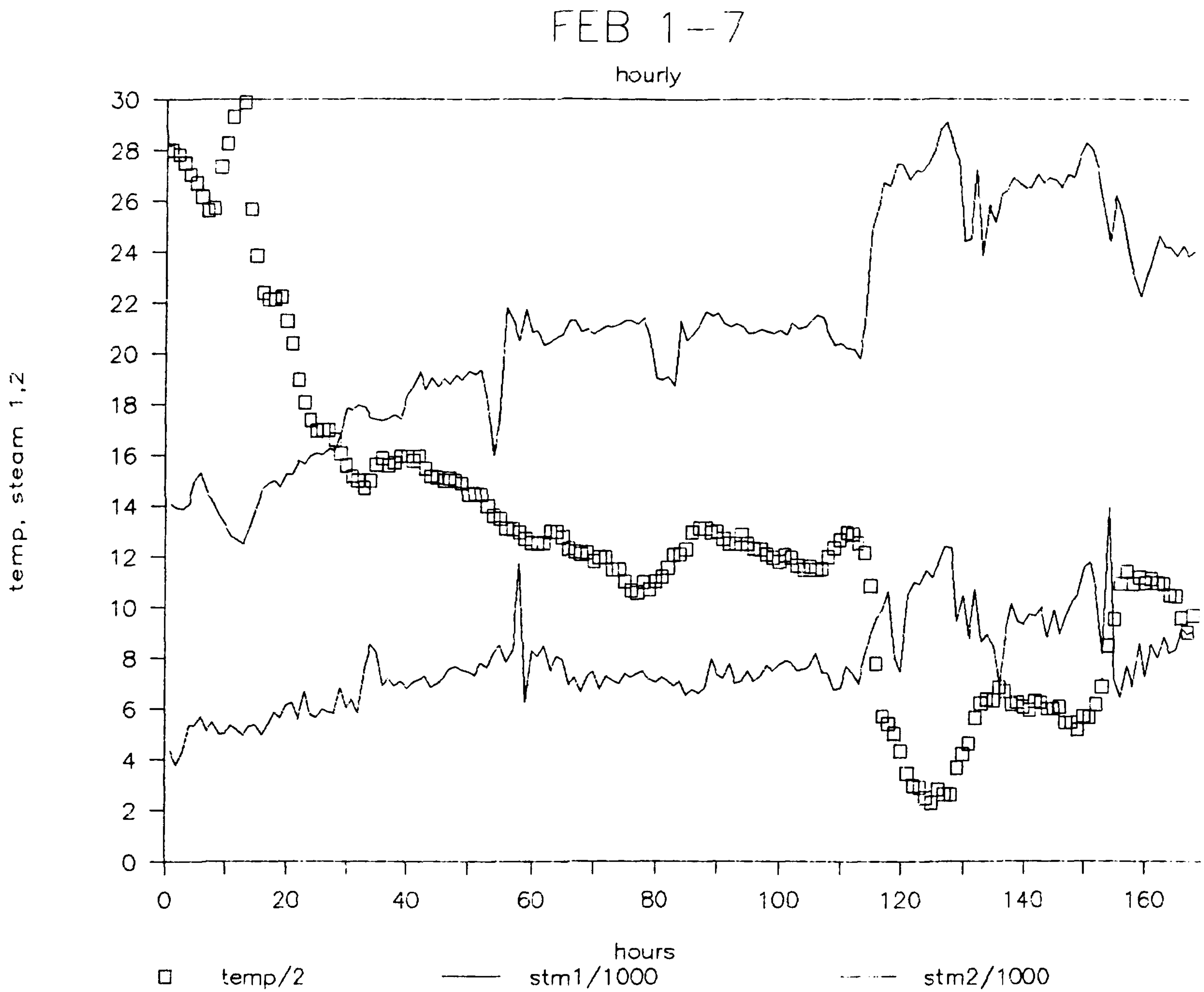
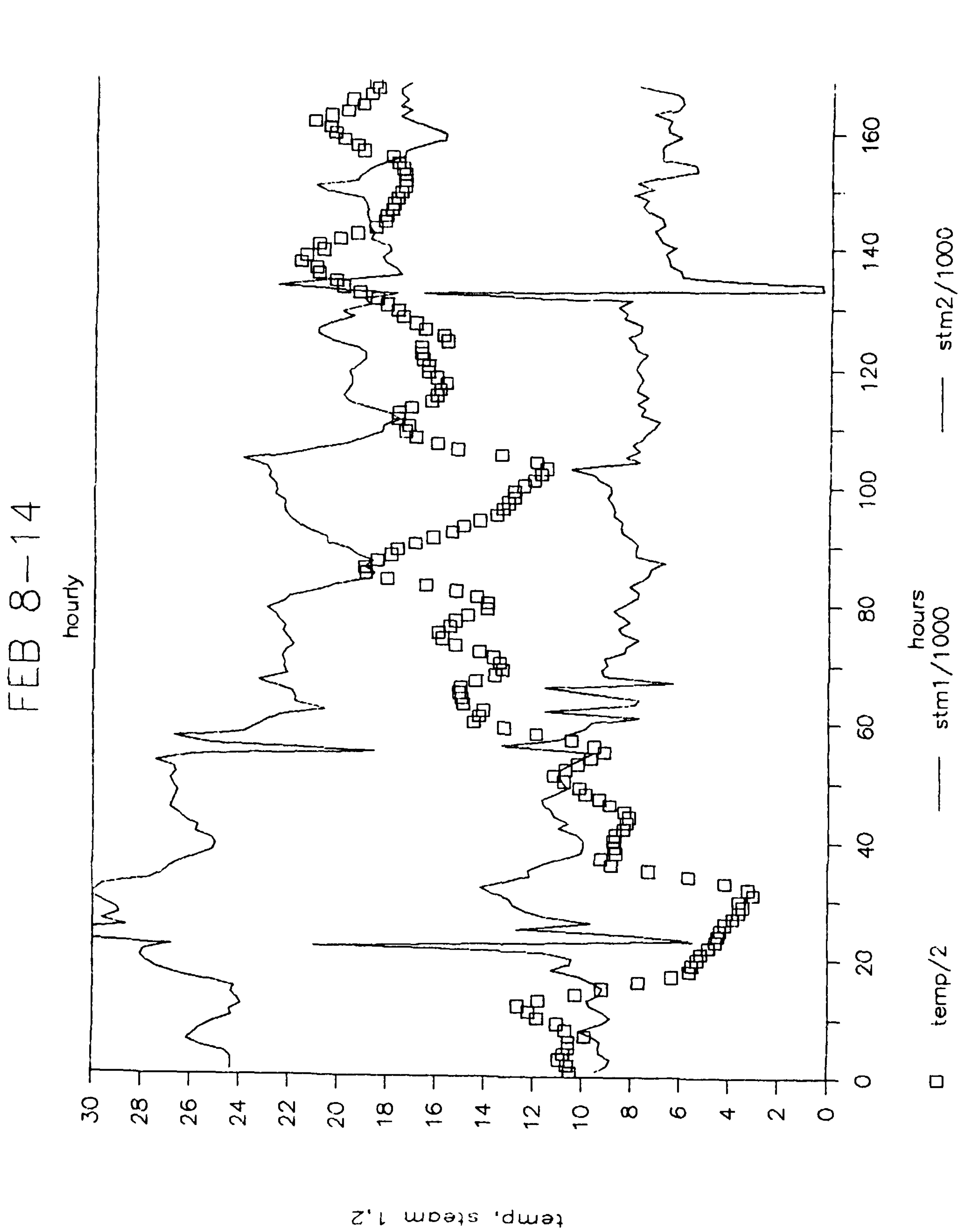
APPENDIX A: Graphs of Hourly Temperature and Steam Flow for February 1989 to March 1989


FEB 1–7
hourly
temp, steam 1,2
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
hours
temp/2
stm1/1000
stm2/1000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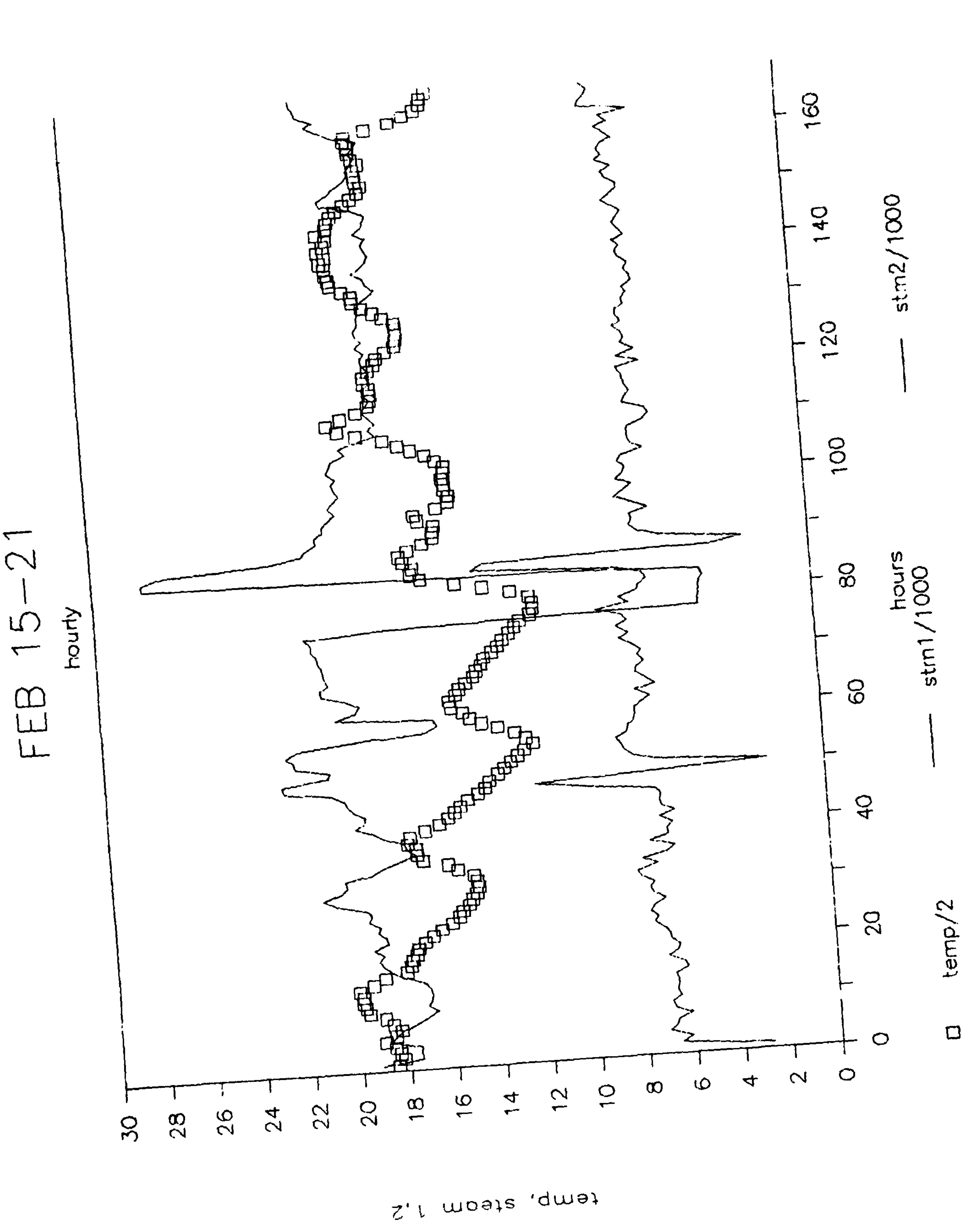
hourly
temp, steam 1,2
hours
temp/2
stm1/1000
stm2/1000


FEB 15–21
hourly
temp, steam 1,2
hours
temp/2
stm1/1000
stm2/1000
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20
40
60
80
100
120
140
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0
2
4
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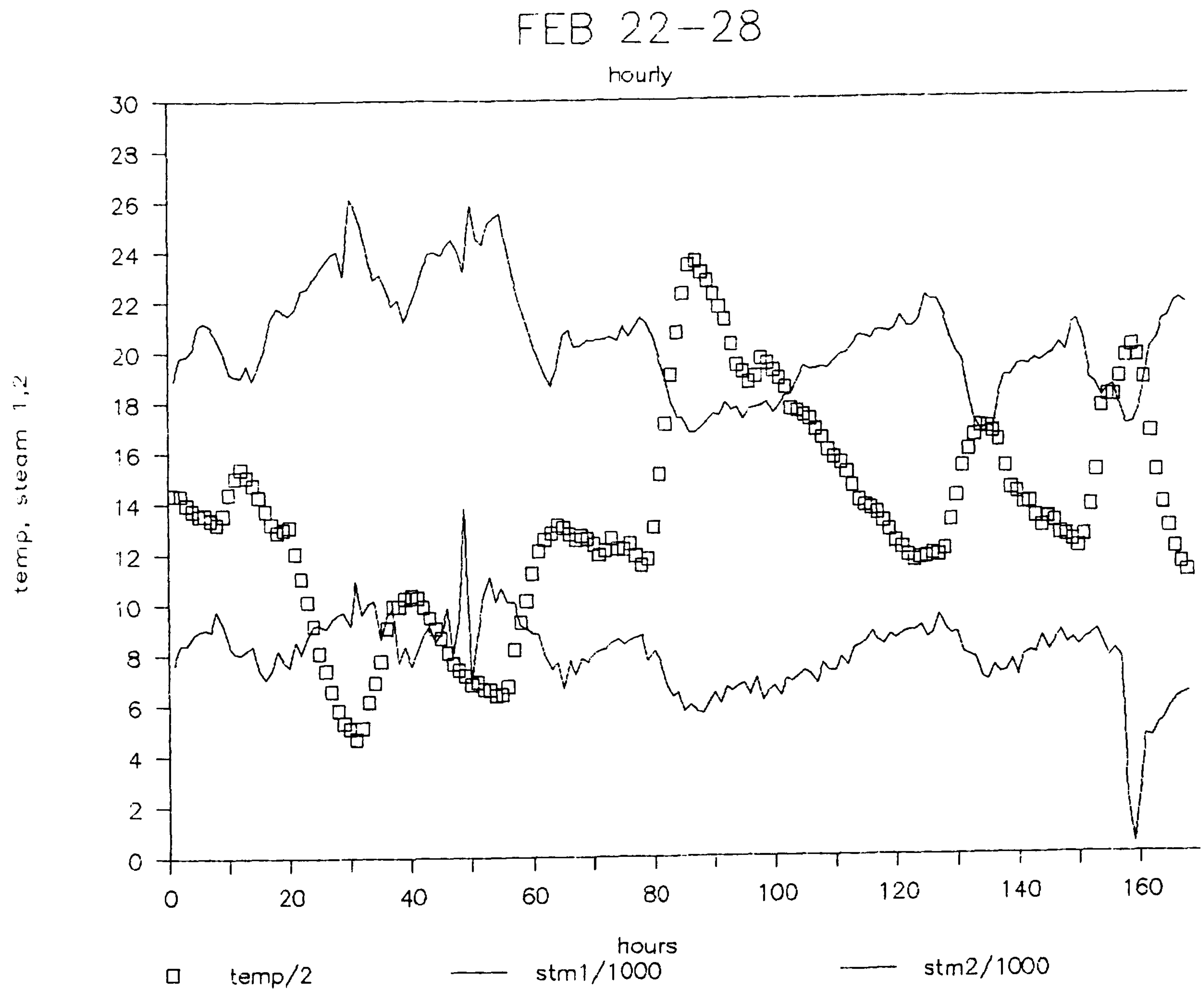
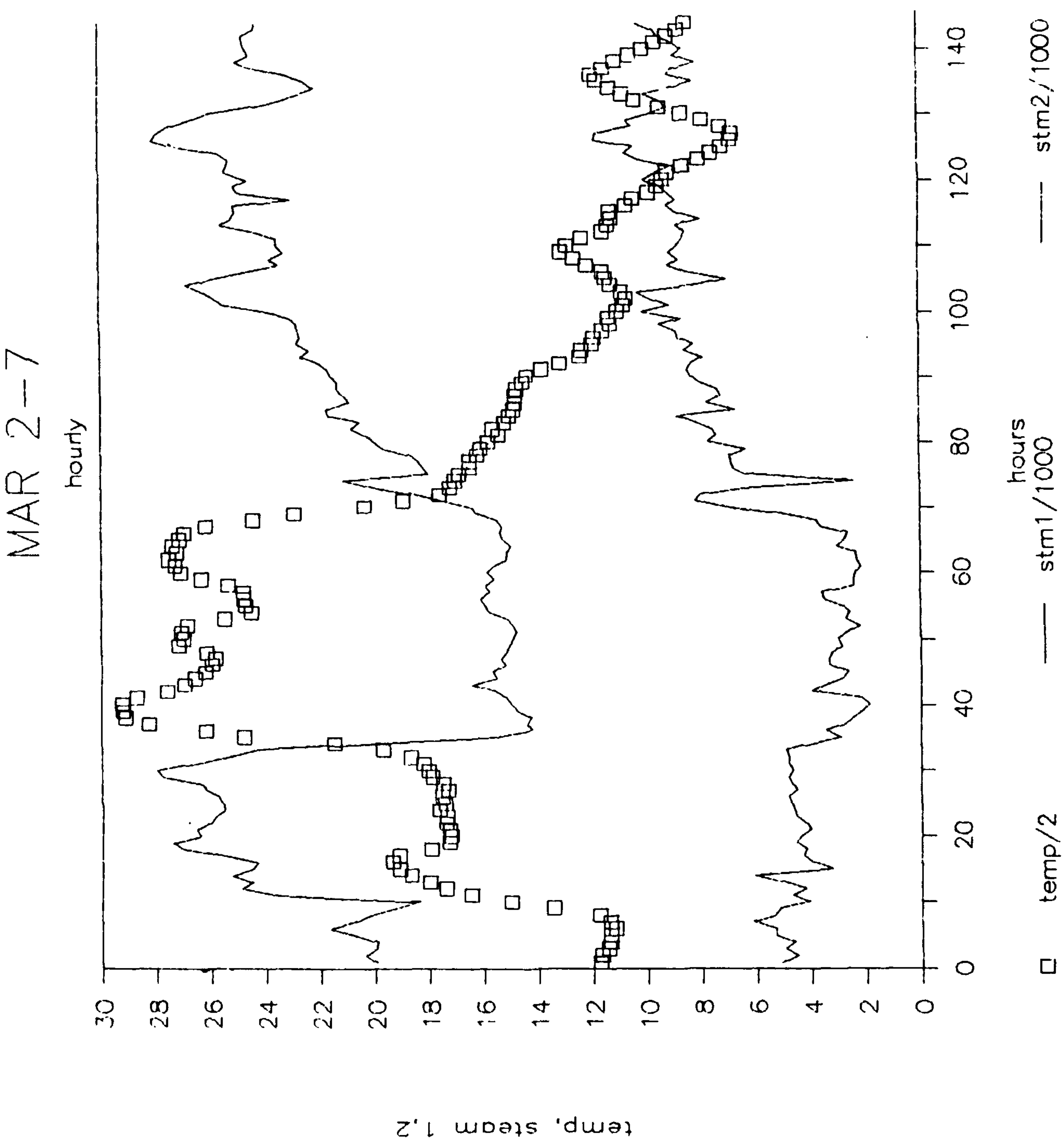
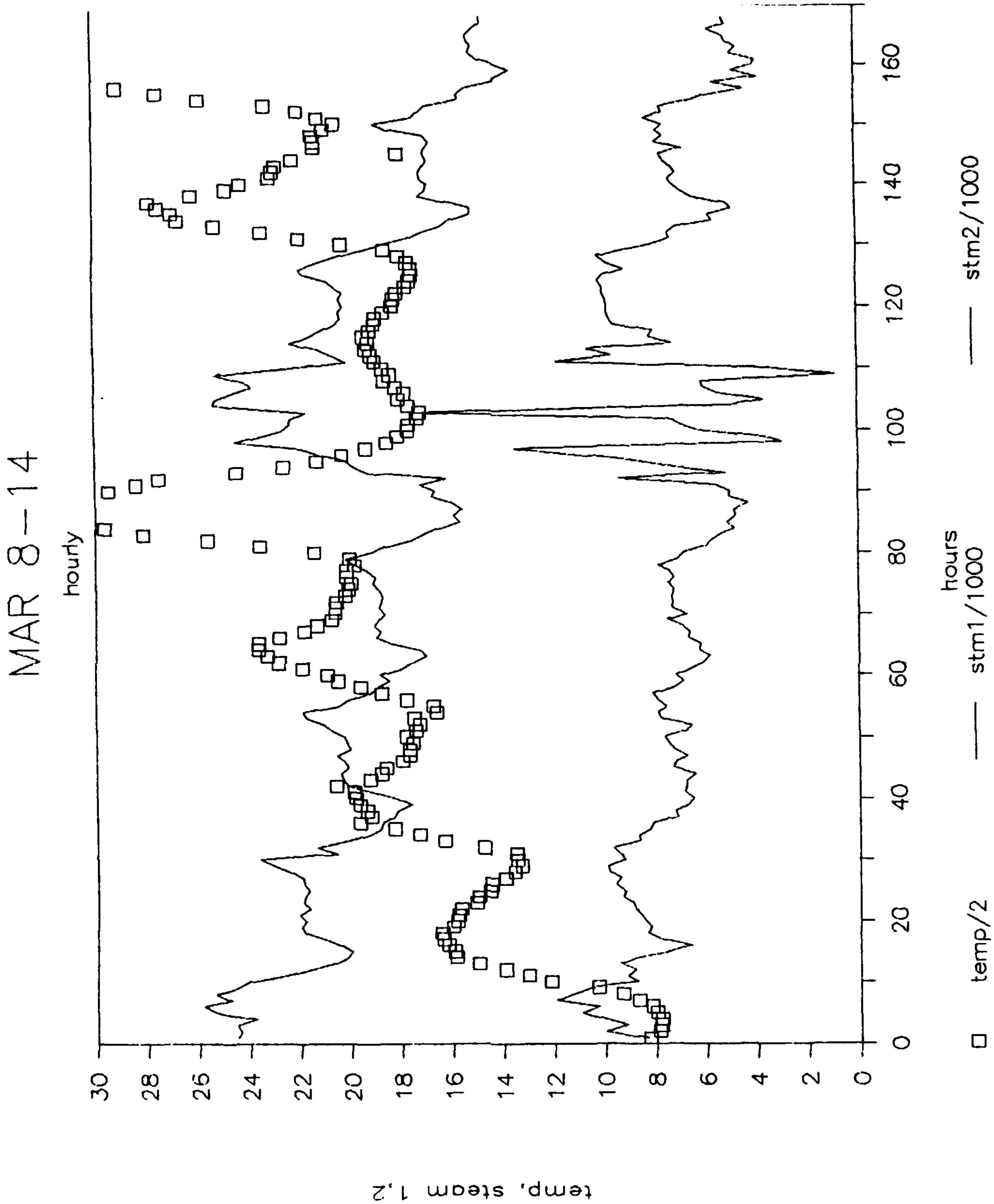
16
18
20
22
24
26
28
30



FEB 22-28
hourly
temp, steam 1,2
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
hours
temp/2
stm1/1000
stm2/1000


MAR 2—7
hourly
hours
temp, steam 1,2
temp/2
stm1/1000
stm2/1000


MAR 8-14
hourly
temp, steam 1,2
hours
temp/2
stm1/1000
stm2/1000
0
20
40
60
80
100
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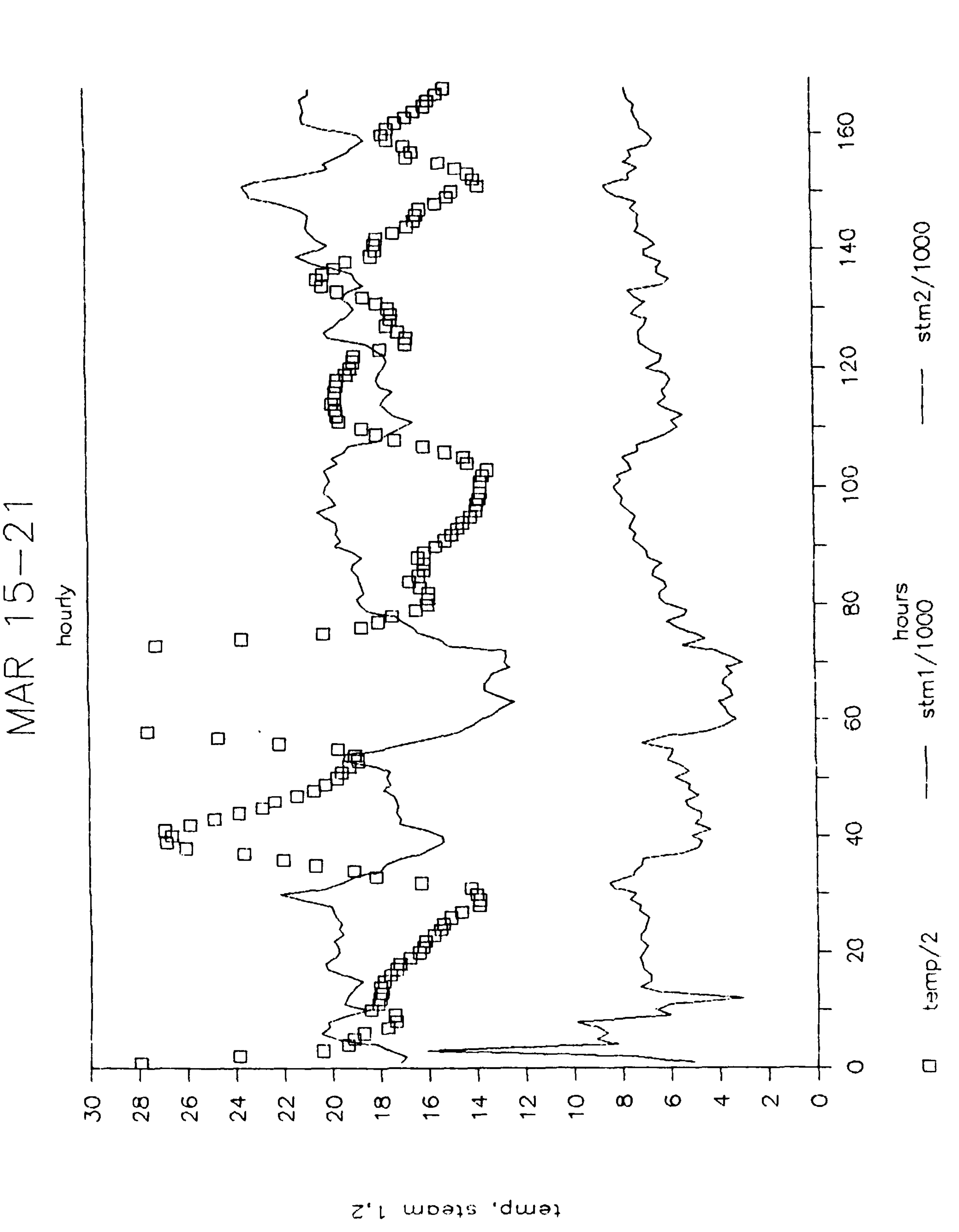
22
24
26
28
30


MAR 15—21
hourly
hours
temp, steam 1,2
temp/2
stm1/1000
stm2/1000
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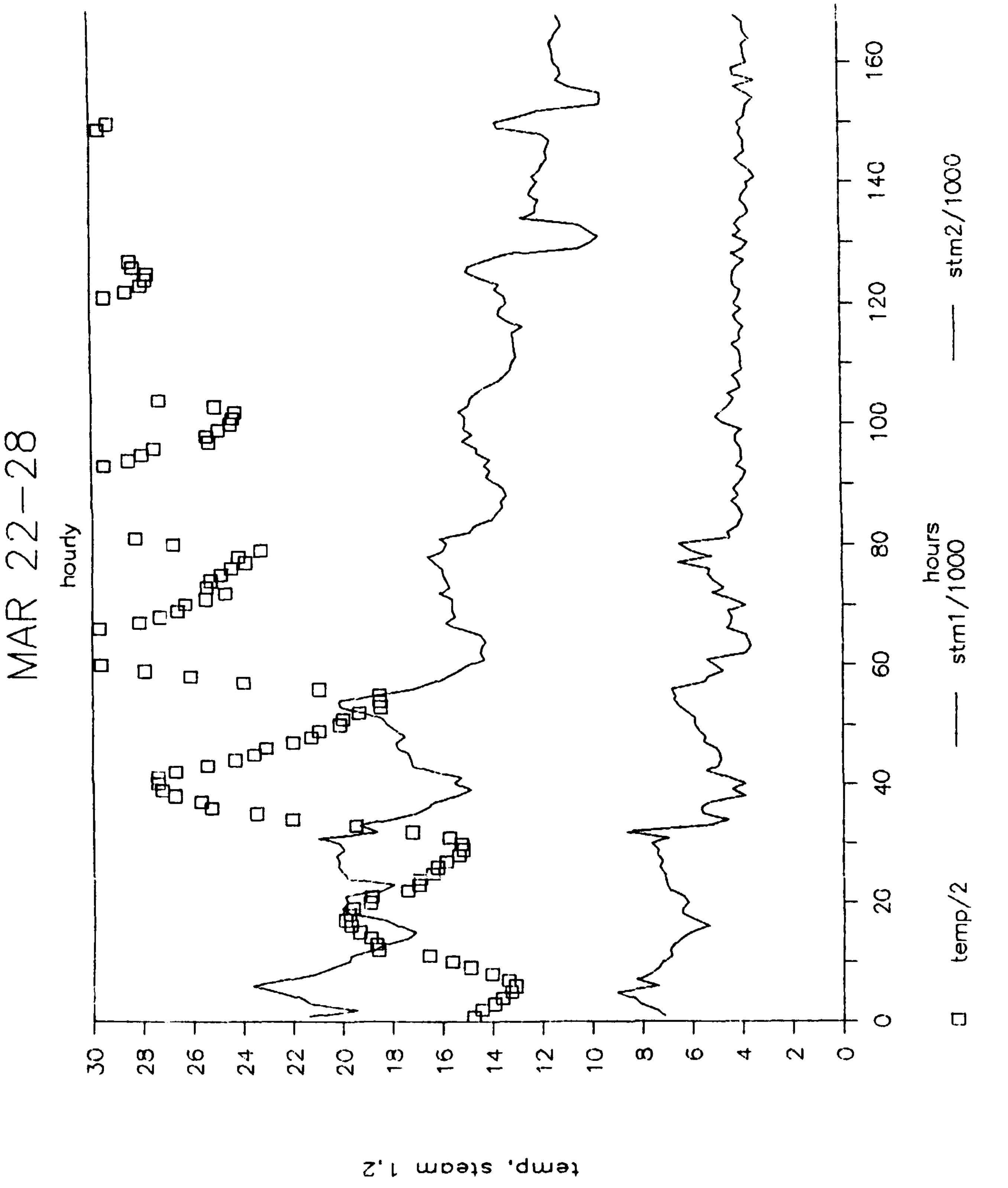
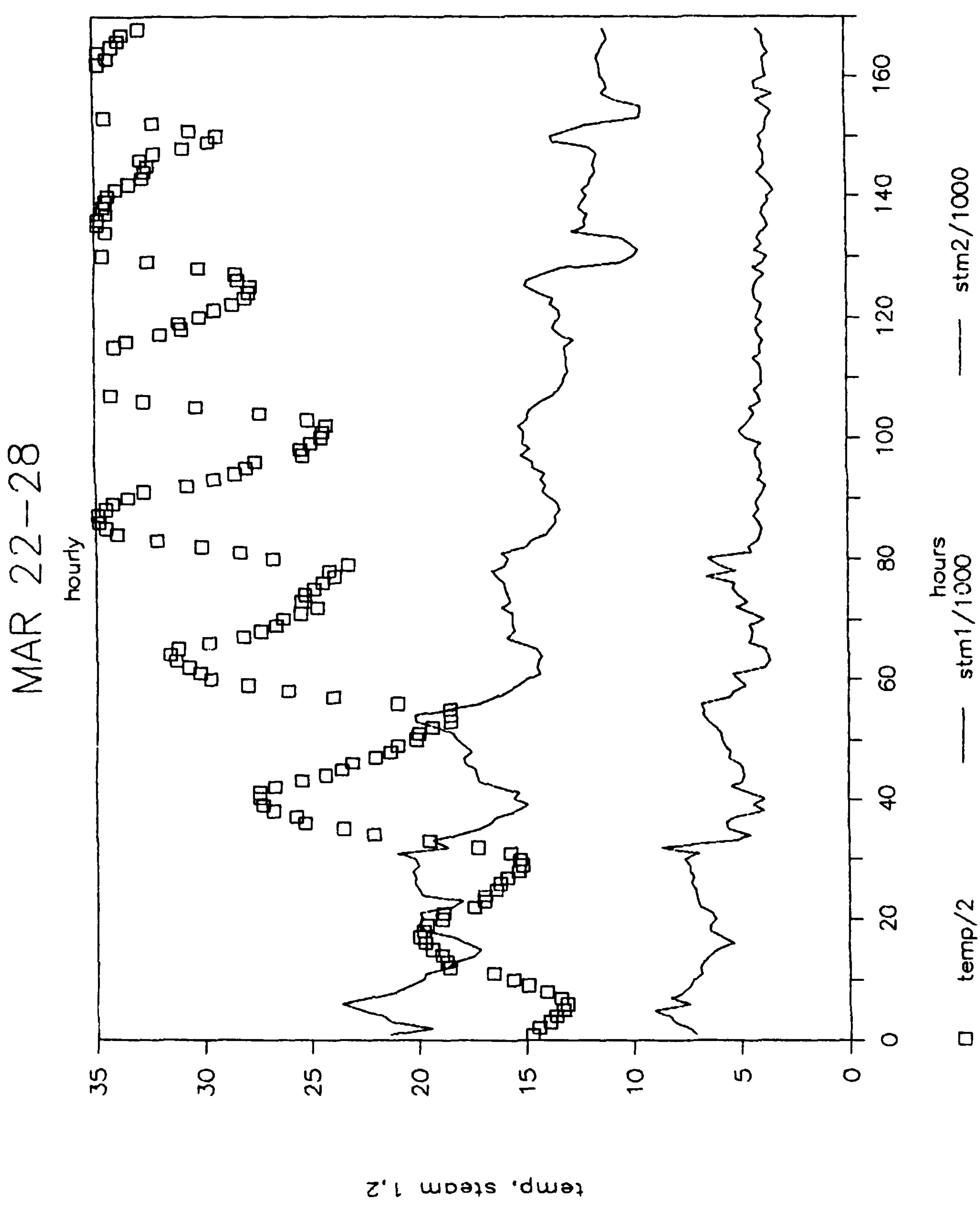
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30


MAR 22-28
hourly
temp, steam 1,2
hours
temp/2
stm1/1000
stm2/1000


MAR 22-28
hourly
temp, steam 1,2
hours
temp/2
stm1/1000
stm2/1000

APPENDIX B: Tables of Hourly Temperature and Steam Flow

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
1	1	1	0	28	56.0000	4351.42	14070.7
2	2	2	1	28	55.6667	3816.25	13920.8
3	3	3	2	28	55.0000	4302.17	13878.3
4	4	4	3	28	54.0833	5354.50	14113.0
5	5	5	4	28	53.4167	5339.25	14977.7
6	6	6	5	28	52.3333	5713.17	15317.3
7	7	7	6	28	51.2500	5129.08	14590.2
8	8	8	7	28	51.4167	5453.92	14133.8
9	9	9	8	28	54.6667	5002.42	13585.0
10	10	10	9	28	56.5000	5041.67	13211.2
11	11	11	10	28	58.5833	5349.58	12786.6
12	12	12	11	28	61.4167	5168.17	12641.1
13	13	13	12	28	59.7500	4938.92	12470.8
14	14	14	13	28	51.3333	5327.58	13111.7
15	15	15	14	28	47.6667	5346.00	13893.3
16	16	16	15	28	44.7500	4941.42	14632.5
17	17	17	16	28	44.2500	5380.08	14884.7
18	18	18	17	28	44.2500	5854.42	14998.8
19	19	19	18	28	44.4167	5612.33	14709.0
20	20	20	19	28	42.5833	6131.42	15243.0
21	21	21	20	28	40.7500	6247.33	15228.8
22	22	22	21	28	37.9167	5546.92	15769.8
23	23	23	22	28	36.1667	6681.33	15667.6
24	24	24	23	28	34.7500	5762.75	15979.7
25	25	25	0	28	33.9167	5643.67	16074.8
26	26	26	1	28	34.0000	5991.17	16027.3
27	27	27	2	28	34.0000	5847.50	16257.8
28	28	28	3	28	33.2500	5821.83	16181.3
29	29	29	4	28	32.1667	6840.92	16850.5
30	30	30	5	28	31.1667	6025.50	17848.3
31	31	31	6	28	30.3333	6406.08	17749.9
32	32	32	7	28	30.0000	5820.75	17968.7
33	33	33	8	28	29.4167	7645.00	17861.5
34	34	34	9	28	30.0000	8565.83	17485.9
35	35	35	10	28	31.2500	8220.08	17400.1
36	36	36	11	28	31.7500	6922.67	17366.7
37	37	37	12	28	31.1667	7213.75	17420.3
38	38	38	13	28	31.4167	6901.92	17603.4
39	39	39	14	28	31.9167	7087.50	17450.6
40	40	40	15	28	31.9167	6805.75	18394.1
41	41	41	16	28	31.5833	7054.25	18745.1
42	42	42	17	28	31.9167	7155.17	19264.2
43	43	43	18	28	30.9167	7284.25	18576.2
44	44	44	19	28	30.3333	6835.50	19038.8
45	45	45	20	28	30.2500	7002.83	18713.3
46	46	46	21	28	30.0000	7211.42	19015.1
47	47	47	22	28	30.1667	7592.33	18304.2
48	48	48	23	28	30.0000	7645.08	19145.9
49	49	49	0	28	29.7500	7535.58	18954.7
50	50	50	1	28	28.9167	7486.83	19309.5
51	51	51	2	28	29.0000	7316.67	19202.8
52	52	52	3	28	28.9167	7831.25	19362.4
53	53	53	4	28	28.0000	7614.67	18151.1
54	54	54	5	28	27.2500	8220.00	16097.8
55	55	55	6	28	27.0000	8533.58	17428.0

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OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
56	56	56	7	28	26.2500	7861.0	21857.5
57	57	57	8	28	26.1667	8356.7	21285.3
58	58	58	9	28	25.9167	11716.8	20535.8
59	59	59	10	28	25.4167	6267.3	21742.1
60	60	60	11	28	25.0833	8301.3	20854.8
61	61	61	12	28	25.0000	8072.8	20890.5
62	62	62	13	28	25.0833	8484.0	20302.2
63	63	63	14	28	26.0000	7514.2	20470.0
64	64	64	15	28	26.0000	8085.9	20647.2
65	65	65	16	28	25.5000	7949.8	20768.2
66	66	66	17	28	24.6667	6931.6	21325.6
67	67	67	18	28	24.4167	7270.9	21315.7
68	68	68	19	28	24.2500	6677.5	20870.1
69	69	69	20	28	24.3333	7294.2	20951.3
70	70	70	21	28	23.6667	7469.1	20779.6
71	71	71	22	28	23.9167	6789.2	20926.1
72	72	72	23	28	23.9167	7289.2	21088.5
73	73	73	0	28	23.0000	7157.9	21058.7
74	74	74	1	28	23.0000	6994.6	21138.9
75	75	75	2	28	22.0833	7400.6	21322.3
76	76	76	3	28	21.3333	7252.3	21308.5
77	77	77	4	28	21.1667	7400.0	21156.5
78	78	78	5	28	22.0000	7460.1	21380.2
79	79	79	6	28	21.4167	7192.7	20667.2
80	80	80	7	28	22.0833	7070.2	19014.5
81	81	81	8	28	22.4167	7296.3	18947.7
82	82	82	9	28	23.1667	7120.3	19076.8
83	83	83	10	28	24.1667	6899.2	18722.5
84	84	84	11	28	24.2500	7131.7	21327.4
85	85	85	12	28	24.5833	6552.1	20520.8
86	86	86	13	28	25.9167	6773.3	20758.5
87	87	87	14	28	26.2500	6615.9	21133.1
88	88	88	15	28	26.2500	6844.4	21647.7
89	89	89	16	28	25.9167	7981.0	21464.6
90	90	90	17	28	26.0000	7387.8	21600.2
91	91	91	18	28	25.4167	7229.7	21192.9
92	92	92	19	28	25.0000	7791.0	21058.0
93	93	93	20	28	25.0000	7042.4	21168.8
94	94	94	21	28	25.7500	7097.9	21081.5
95	95	95	22	28	25.0000	7491.8	20804.7
96	96	96	23	28	24.6667	7102.2	20830.3
97	97	97	0	28	24.5833	7329.1	20953.3
98	98	98	1	28	24.2500	7727.7	20873.2
99	99	99	2	28	23.9167	7522.2	20815.2
100	100	100	3	28	23.6667	7772.3	20907.9
101	101	101	4	28	24.1667	7888.8	20738.8
102	102	102	5	28	23.9167	7868.5	21200.8
103	103	103	6	28	23.3333	7557.3	20975.0
104	104	104	7	28	23.0000	7572.9	21048.3
105	105	105	8	28	23.2500	7690.1	21292.0
106	106	106	9	28	23.0000	8199.9	21530.7
107	107	107	10	28	23.0833	7424.8	21435.7
108	108	108	11	28	24.0000	7432.1	20803.5
109	109	109	12	28	24.7500	6783.8	20357.3
110	110	110	13	28	25.3333	6806.6	20419.3

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OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
111	111	111	14	28	25.9167	7693.9	20235.8
112	112	112	15	28	25.8333	7396.1	20184.4
113	113	113	16	28	25.0833	6990.8	19795.3
114	114	114	17	28	24.3333	8082.3	21218.3
115	115	115	18	28	21.7500	8904.4	24896.8
116	116	116	19	28	15.5833	9596.6	25777.0
117	117	117	20	28	11.4167	9883.1	26722.2
118	118	118	21	28	10.8333	10659.4	26619.9
119	119	119	22	28	10.0833	8022.3	27451.8
120	120	120	23	28	8.6667	7476.8	27457.8
121	121	121	0	28	6.9167	10498.3	26855.3
122	122	122	1	28	5.9167	11003.1	27223.8
123	123	123	2	28	5.8333	10933.7	27163.6
124	124	124	3	28	5.0000	11472.1	27468.4
125	125	125	4	28	4.5833	11176.1	27942.0
126	126	126	5	28	5.5833	11717.0	28778.8
127	127	127	6	28	5.2500	12389.9	29081.5
128	128	128	7	28	5.2500	12360.2	28118.9
129	129	129	8	28	7.3333	9439.0	27605.4
130	130	130	9	28	8.4167	10441.4	24425.3
131	131	131	10	28	9.2500	8769.9	24513.2
132	132	132	11	28	11.2500	10719.8	27238.9
133	133	133	12	28	12.4167	8648.3	23885.5
134	134	134	13	28	12.7500	8951.3	25874.8
135	135	135	14	28	12.6667	8462.8	25184.5
136	136	136	15	28	13.6667	6952.4	26242.6
137	137	137	16	28	13.3333	8824.0	26423.4
138	138	138	17	28	12.3333	10145.8	26924.9
139	139	139	18	28	12.5000	9456.9	26711.6
140	140	140	19	28	12.1667	9304.2	26496.0
141	141	141	20	28	11.9167	9744.8	26520.8
142	142	142	21	28	12.5833	9651.3	27072.1
143	143	143	22	28	12.5000	10002.9	26693.0
144	144	144	23	28	12.0000	8815.1	26909.5
145	145	145	0	28	12.0000	9899.9	26827.7
146	146	146	1	28	12.1667	8899.0	26506.7
147	147	147	2	28	10.9167	9662.5	27040.2
148	148	148	3	28	10.9167	10251.8	26921.8
149	149	149	4	28	10.3333	10538.6	27737.3
150	150	150	5	28	11.4167	11571.2	28281.3
151	151	151	6	28	11.3333	11776.7	28019.9
152	152	152	7	28	12.3333	10385.6	27159.9
153	153	153	8	28	13.7500	8155.7	25679.5
154	154	154	9	28	17.0000	13959.3	24421.6
155	155	155	10	28	19.0833	7171.8	26217.7
156	156	156	11	28	21.8333	6469.7	25425.7
157	157	157	12	28	22.8333	7687.0	24065.4
158	158	158	13	28	21.8333	6880.0	23034.1
159	159	159	14	28	22.3333	8570.3	22268.1
160	160	160	15	28	21.9167	7276.3	23039.0
161	161	161	16	28	22.2500	8553.8	23667.9
162	162	162	17	28	21.9167	8027.2	24641.3
163	163	163	18	28	21.8333	8836.1	24210.7
164	164	164	19	28	21.0000	8190.2	24208.5
165	165	165	20	28	20.9167	8332.3	23825.3

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OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
166	166	166	21	28	19.1667	9153.0	24257.1
167	167	167	22	28	18.0833	8963.0	23829.7
168	168	168	23	28	19.4167	9067.3	24051.5
169	169	1	0	28	21.0083	9457.6	24347.0
170	170	2	1	29	21.2417	9000.2	24342.1
171	171	3	2	29	21.9000	8888.1	24355.8
172	172	4	3	29	21.5667	9302.2	24613.7
173	173	5	4	29	21.1333	9332.1	25606.0
174	174	6	5	29	21.1333	9264.9	26157.2
175	175	7	6	29	19.8667	9681.3	25875.5
176	176	8	7	29	21.4083	10146.5	25671.2
177	177	9	8	29	22.1583	9218.1	25050.3
178	178	10	9	29	23.8083	8883.1	24340.1
179	179	11	10	29	24.4583	9180.8	24432.8
180	180	12	11	29	25.3750	9729.7	23975.6
181	181	13	12	29	23.6167	9830.7	24123.7
182	182	14	13	29	20.6000	9355.7	24339.6
183	183	15	14	29	18.4417	9182.7	24271.7
184	184	16	15	29	15.4583	9665.8	25433.9
185	185	17	16	29	12.7417	10120.9	26639.1
186	186	18	17	29	11.2500	11321.1	27418.2
187	187	19	18	29	11.0833	10558.7	27816.5
188	188	20	19	29	10.6083	10444.1	28083.2
189	189	21	20	29	10.3167	11695.7	27934.6
190	190	22	21	29	9.7083	20991.6	26756.5
191	191	23	22	29	9.0917	5482.8	33036.3
192	192	24	23	29	8.9417	8062.6	31437.6
193	193	25	0	29	8.7583	12748.2	28611.5
194	194	26	1	29	8.3167	9661.2	29630.9
195	195	27	2	29	7.6833	11619.6	28924.9
196	196	28	3	29	7.2083	12384.3	29048.3
197	197	29	4	29	6.8833	12862.4	29598.4
198	198	30	5	29	7.1750	13007.7	30090.6
199	199	31	6	29	6.0333	13654.6	29874.1
200	200	32	7	29	6.4667	14205.8	29602.7
201	201	33	8	29	8.3500	13060.2	27632.7
202	202	34	9	29	11.3500	12163.7	27179.5
203	203	35	10	29	14.6167	12226.9	26890.5
204	204	36	11	29	17.6667	11630.2	26454.3
205	205	37	12	29	18.5417	10864.1	25799.7
206	206	38	13	29	17.3583	10094.0	25140.7
207	207	39	14	29	17.4583	10024.2	25012.6
208	208	40	15	29	17.5750	10030.0	25167.9
209	209	41	16	29	17.3917	10283.5	25828.8
210	210	42	17	29	16.7167	11044.1	25745.3
211	211	43	18	29	16.4917	10603.4	26216.3
212	212	44	19	29	16.2917	11188.4	26472.0
213	213	45	20	29	16.6583	11311.6	26863.0
214	214	46	21	29	17.8750	11626.0	26769.5
215	215	47	22	29	18.6833	11699.6	26672.3
216	216	48	23	29	19.8583	11071.8	26576.4
217	217	49	0	29	20.3667	10675.7	26735.1
218	218	50	1	29	21.6333	10885.6	26842.5
219	219	51	2	29	22.4333	10982.6	26626.9
[illegible]	220	52	3	29	21.5000	10933.7	26716.1

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OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
221	221	53	4	29	20.4667	10475.4	27452.1
222	222	54	5	29	19.3667	10005.6	26004.0
223	223	55	6	29	18.3000	9611.1	18540.9
224	224	56	7	29	19.1083	13388.8	25201.1
225	225	57	8	29	20.9833	10915.9	26694.8
226	226	58	9	29	23.8667	10668.1	23910.8
227	227	59	10	29	26.4833	9911.3	23359.1
228	228	60	11	29	28.9500	9672.7	22958.9
229	229	61	12	29	28.5500	7701.6	22402.6
230	230	62	13	29	28.2250	11572.7	20557.6
231	231	63	14	29	29.8417	7932.8	21826.8
232	232	64	15	29	29.9500	7717.9	21789.5
233	233	65	16	29	30.1667	9746.4	21912.7
234	234	66	17	29	30.0583	11602.6	22658.0
235	235	67	18	29	28.8583	6316.2	23271.9
236	236	68	19	29	27.2750	9195.1	22125.6
237	237	69	20	29	26.6750	9290.9	22283.8
238	238	70	21	29	26.9500	9073.3	22266.8
239	239	71	22	29	27.4500	9187.9	22353.5
240	240	72	23	29	28.6083	8379.1	22155.8
241	241	73	0	29	30.5833	8317.0	21868.9
242	242	74	1	29	31.6667	7798.6	22139.5
243	243	75	2	29	31.9417	8447.8	22332.1
244	244	76	3	29	30.9750	8604.4	22236.3
245	245	77	4	29	30.5750	8180.2	22488.5
246	246	78	5	29	29.5750	8495.3	22613.0
247	247	79	6	29	27.9917	8806.9	22960.0
248	248	80	7	29	27.8833	8254.3	22211.6
249	249	81	8	29	28.7917	7844.6	21969.1
250	250	82	9	29	30.5083	7786.4	20850.5
251	251	83	10	29	32.9750	8174.8	20151.1
252	252	84	11	29	36.1667	7676.7	18793.1
253	253	85	12	29	37.8750	7361.9	18569.0
254	254	86	13	29	37.9667	7287.4	18954.1
255	255	87	14	29	36.9417	6708.6	18640.1
256	256	88	15	29	35.7833	7920.0	19310.8
257	257	89	16	29	35.3417	7912.4	19618.8
258	258	90	17	29	33.8833	7818.0	20524.3
259	259	91	18	29	32.4083	8094.4	20520.4
260	260	92	19	29	30.6583	8452.1	21245.5
261	261	93	20	29	29.9333	8514.5	21635.2
262	262	94	21	29	28.6250	8469.9	21956.1
263	263	95	22	29	27.1667	8800.5	22188.7
264	264	96	23	29	26.6833	8785.3	22258.2
265	265	97	0	29	26.2250	8863.9	22230.9
266	266	98	1	29	25.7250	9042.8	22598.5
267	267	99	2	29	25.8000	8954.3	22592.1
268	268	100	3	29	25.0333	8962.4	22670.4
269	269	101	4	29	24.2333	9469.9	22922.3
270	270	102	5	29	23.6583	9660.0	22877.9
271	271	103	6	29	23.1833	10615.9	23004.4
272	272	104	7	29	24.0167	7800.8	23966.0
273	273	105	8	29	26.8500	8374.8	22076.6
274	274	106	9	29	30.4833	7786.5	20920.0
275	275	107	10	29	32.1333	8116.9	19674.2

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OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
276	276	108	11	29	33.9167	7713.2	19014.3
277	277	109	12	29	34.7167	7505.7	18312.2
278	278	110	13	29	34.5167	7189.4	18249.2
279	279	111	14	29	35.3500	7006.2	17604.0
280	280	112	15	29	35.3083	7749.9	18050.5
281	281	113	16	29	34.2833	7593.8	19068.8
282	282	114	17	29	32.6333	7914.8	19689.0
283	283	115	18	29	32.1750	7466.3	19903.8
284	284	116	19	29	31.9167	7913.2	19677.4
285	285	117	20	29	31.4083	7848.9	19563.1
286	286	118	21	29	32.2167	7662.5	19555.9
287	287	119	22	29	32.8917	7840.0	19650.5
288	288	120	23	29	32.9250	7947.6	19381.5
289	289	121	0	29	33.3250	7780.0	19034.0
290	290	122	1	29	33.4750	7514.7	19025.0
291	291	123	2	29	33.5167	7956.4	19310.1
292	292	124	3	29	31.3333	8006.3	20313.6
293	293	125	4	29	31.6667	8257.9	20936.8
294	294	126	5	29	33.1250	7769.4	20914.3
295	295	127	6	29	33.9083	7715.2	20396.8
296	296	128	7	29	34.9917	8436.9	19504.8
297	297	129	8	29	35.4667	8355.8	19987.9
298	298	130	9	29	36.3083	8708.2	18862.9
299	299	131	10	29	37.1417	8153.5	19073.1
300	300	132	11	29	38.5917	16701.7	17784.2
301	301	133	12	29	39.9750	365.1	22643.0
302	302	134	13	29	40.5333	389.0	20513.8
303	303	135	14	29	41.8917	6117.2	17590.7
304	304	136	15	29	42.1083	6188.8	17815.8
305	305	137	16	29	43.3667	6623.4	18179.7
306	306	138	17	29	42.9333	6648.0	18372.9
307	307	139	18	29	41.5583	6775.2	18006.9
308	308	140	19	29	41.9000	6360.4	18137.9
309	309	141	20	29	40.1667	6938.8	18866.6
310	310	142	21	29	38.8167	7092.1	18693.4
311	311	143	22	29	37.2833	7254.3	18924.3
312	312	144	23	29	36.5250	6831.0	18893.5
313	313	145	0	29	36.3667	6933.0	18971.9
314	314	146	1	29	35.9750	7458.4	18936.0
315	315	147	2	29	35.8250	7725.3	19023.4
316	316	148	3	29	35.4833	7502.5	19178.1
317	317	149	4	29	35.1750	8112.1	20558.1
318	318	150	5	29	34.8750	7289.7	21046.0
319	319	151	6	29	34.8000	7932.6	19378.4
320	320	[illegible]	7	29	34.8917	6833.0	19198.3
321	32[illegible]	[illegible]3	8	29	35.0667	5511.2	18837.9
322	322	154	9	29	35.4333	5537.3	18215.4
323	323	155	10	29	35.9000	6947.1	17455.9
324	324	156	11	29	38.2333	6903.2	17405.8
325	325	157	12	29	38.7667	6931.0	16640.1
326	326	158	13	29	39.8083	6721.8	15775.9
327	327	159	14	29	40.6000	6131.5	15761.9
328	328	160	15	29	41.0250	6670.6	16355.4
329	329	161	16	29	42.3167	6747.7	16982.6
330	330	162	17	29	40.9917	6590.3	17664.4

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OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
331	331	163	18	29	39.6333	7321.6	17251.6
332	332	164	19	29	38.3333	6342.2	17693.9
333	333	165	20	29	39.2583	6198.3	17373.3
334	334	166	21	29	37.7667	6181.3	17634.0
335	335	167	22	29	37.1833	6555.1	17664.1
336	336	168	23	29	37.4250	7913.0	17266.4
337	337	1	0	29	37.0333	2793.7	19192.8
338	338	2	1	31	36.5417	6636.5	17457.6
339	339	3	2	31	36.8583	6211.6	17543.0
340	340	4	3	31	37.2167	7125.2	17593.2
341	341	5	4	31	38.0250	6834.4	18797.3
342	342	6	5	31	37.1333	6745.3	18536.0
343	343	7	6	31	36.6833	6152.2	18138.2
344	344	8	7	31	37.2667	6832.1	17649.0
345	345	9	8	31	37.9500	6919.8	17099.3
346	346	10	9	31	39.1667	6553.8	16719.0
347	347	11	10	31	39.4833	6732.7	17166.6
348	348	12	11	31	39.6917	6641.9	16973.5
349	349	13	12	31	39.6167	6658.8	16924.8
350	350	14	13	31	39.9750	6743.7	16988.7
351	351	15	14	31	38.7750	6195.9	17227.1
352	352	16	15	31	37.7667	6362.9	18025.7
353	353	17	16	31	35.9000	7006.4	18540.3
354	354	18	17	31	35.4917	6579.0	18917.2
355	355	19	18	31	35.3167	6565.1	19069.0
356	356	20	19	31	34.9167	6808.1	18841.4
357	357	21	20	31	34.7083	6877.1	19225.2
358	358	22	21	31	34.1417	7059.1	18606.3
359	359	23	22	31	33.4750	7471.1	18706.9
360	360	24	23	31	32.7333	7317.9	19035.0
361	361	25	0	31	31.8667	7617.1	18916.2
362	362	26	1	31	31.2083	7392.3	19367.9
363	363	27	2	31	30.8667	6974.1	19250.1
364	364	28	3	31	30.3083	7421.1	19456.8
365	365	29	4	31	29.9833	7572.2	20670.0
366	366	30	5	31	29.5917	7364.0	21241.2
367	367	31	6	31	29.3667	7889.7	20547.2
368	368	32	7	31	29.5083	8061.1	20190.0
369	369	33	8	31	29.7333	7183.2	20278.8
370	370	34	9	31	31.0750	7840.4	19122.3
371	371	35	10	31	31.8083	6767.2	18655.4
372	372	36	11	31	33.9250	6427.4	17863.8
373	373	37	12	31	34.3417	7477.0	17232.8
374	374	38	13	31	34.4417	6693.8	17596.1
375	375	39	14	31	35.1083	6727.3	17671.5
376	376	40	15	31	34.8583	6476.1	18554.8
377	377	41	16	31	33.5583	6981.4	18937.7
378	378	42	17	31	32.3417	6315.7	19688.5
379	379	43	18	31	31.5333	6854.1	19321.1
380	380	44	19	31	31.0167	6944.9	19251.2
381	381	45	20	31	30.4667	6877.3	19726.6
382	382	46	21	31	29.8417	7100.9	19986.5
383	383	47	22	31	28.9750	9800.8	20055.6
384	384	48	23	31	28.3083	12091.9	20574.7
385	385	49	0	31	27.9833	7801.9	22583.0

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
386	386	50	1	31	27.2083	2351.3	22685.8
387	387	51	2	31	26.6417	7024.3	20696.8
388	388	52	3	31	26.0250	7951.6	20615.8
389	389	53	4	31	25.4250	8272.7	22024.1
390	390	54	5	31	24.8333	8417.5	22092.9
391	391	55	6	31	24.0917	8591.5	22430.4
392	392	56	7	31	24.6250	8099.9	21935.3
393	393	57	8	31	25.5417	8035.6	19324.5
394	394	58	9	31	26.9667	7799.2	16484.2
395	395	59	10	31	28.2583	7720.5	16005.5
396	396	60	11	31	29.2250	7733.5	16165.0
397	397	61	12	31	29.8000	7488.1	20229.2
398	398	62	13	31	30.7500	7060.2	19375.6
399	399	63	14	31	30.8083	7626.9	19163.3
400	400	64	15	31	30.2333	6795.3	19665.3
401	401	65	16	31	29.9250	7138.3	20723.7
402	402	66	17	31	29.3667	7559.5	20774.9
403	403	67	18	31	28.7000	7508.6	20415.7
404	404	68	19	31	28.3750	7190.6	20549.4
405	405	69	20	31	27.9500	7427.5	20612.8
406	406	70	21	31	27.7167	7281.4	20636.9
407	407	71	22	31	27.0417	7673.7	20807.6
408	408	72	23	31	26.4833	8176.7	20823.1
409	409	73	0	31	26.0417	7768.5	21026.8
410	410	74	1	31	25.4333	8236.8	21024.1
411	411	75	2	31	24.9417	7760.8	21297.3
412	412	76	3	31	24.4667	7943.5	17745.1
413	413	77	4	31	23.5583	9038.5	4740.6
414	414	78	5	31	23.2833	7625.8	4754.5
415	415	79	6	31	23.3167	8035.7	4710.3
416	416	80	7	31	23.6083	7252.9	4661.2
417	417	81	8	31	25.1000	7148.2	4644.6
418	418	82	9	31	27.4167	6847.7	4496.5
419	419	83	10	31	29.7000	7033.7	4622.2
420	420	84	11	31	32.5000	8336.1	12320.2
421	421	85	12	31	33.3000	14136.7	27893.0
422	422	86	13	31	33.0833	13636.8	27886.6
423	423	87	14	31	33.8750	4137.8	27050.1
424	424	88	15	31	34.1583	2739.5	22630.5
425	425	89	16	31	33.4333	6159.8	21121.2
426	426	90	17	31	32.1500	7061.0	20947.7
427	427	91	18	31	31.2500	7364.7	20510.3
428	428	92	19	31	31.2033	7262.9	20544.4
429	429	93	20	31	31.0333	7352.7	20186.4
430	430	94	21	31	32.3833	6557.3	20182.7
431	431	95	22	31	32.6667	7208.6	19877.4
432	432	96	23	31	30.7250	7917.1	19576.7
433	433	97	0	31	29.7417	7511.7	19884.3
434	434	98	1	31	29.6417	7163.4	19640.0
435	435	99	2	31	30.0000	7800.1	19374.8
436	436	100	3	31	29.9167	7472.5	19551.6
437	437	101	4	31	30.1250	7388.9	19661.9
438	438	102	5	31	29.9000	7656.0	19460.9
439	439	103	6	31	29.8667	7516.8	19855.4
440	440	104	7	31	30.5417	6595.0	19705.4

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
441	441	105	8	31	31.3250	7051.90	19602.5
442	442	106	9	31	32.5083	7156.57	18996.2
443	443	107	10	31	33.5417	7138.98	19229.5
444	444	108	11	31	34.7583	7112.72	18492.3
445	445	109	12	31	36.9333	6481.39	17700.0
446	446	110	13	31	38.4583	6249.61	17948.8
447	447	111	14	31	39.3583	6362.13	17655.8
448	448	112	15	31	38.1667	7291.03	17898.0
449	449	113	16	31	36.8417	7108.99	18159.9
450	450	114	17	31	35.8250	6943.58	18037.5
451	451	115	18	31	35.6667	7132.34	17814.8
452	452	116	19	31	35.5000	7176.90	18053.6
453	453	117	20	31	35.5500	7206.55	18104.9
454	454	118	21	31	35.9833	7455.22	17737.3
455	455	119	22	31	36.0167	6475.33	17872.3
456	456	120	23	31	35.5833	7385.16	17749.5
457	457	121	0	31	35.0750	6603.19	18052.6
458	458	122	1	31	34.7833	7154.33	18071.0
459	459	123	2	31	34.0333	7022.31	17912.9
460	460	124	3	31	33.2000	7117.21	18262.8
461	461	125	4	31	33.1167	7471.97	17976.2
462	462	126	5	31	33.0500	7077.46	18195.9
463	463	127	6	31	33.0083	7298.81	18268.6
464	464	128	7	31	33.1083	7285.77	18081.9
465	465	129	8	31	34.0333	6931.19	18098.9
466	466	130	9	31	34.8167	6995.42	18053.6
467	467	131	10	31	35.7000	6786.52	18030.0
468	468	132	11	31	36.4500	6930.55	17968.4
469	469	133	12	31	36.5167	6553.17	17578.2
470	470	134	13	31	37.2833	6593.93	17288.4
471	471	135	14	31	38.2583	6813.41	17608.8
472	472	136	15	31	38.3500	6650.04	17714.3
473	473	137	16	31	38.5750	6981.43	18173.9
474	474	138	17	31	38.5667	7104.05	17797.9
475	475	139	18	31	38.9167	6941.96	17524.5
476	476	140	19	31	38.5083	7223.01	17422.2
477	477	141	20	31	39.0833	6726.21	17588.9
478	478	142	21	31	38.5167	6943.93	17688.9
479	479	143	22	31	38.3250	7146.65	17473.6
480	480	144	23	31	39.0417	7004.56	17964.7
481	481	145	0	31	38.2750	6799.80	17590.3
482	482	146	1	31	38.0750	7150.07	17532.0
483	483	147	2	31	37.8250	7552.04	17439.6
484	484	148	3	31	37.2667	7180.79	18037.9
485	485	149	4	31	36.5667	6864.38	19277.0
486	486	150	5	31	35.9583	6875.44	19387.4
487	487	151	6	31	35.3000	7331.27	18913.9
488	488	152	7	31	35.0333	7481.82	18635.5
489	489	153	8	31	35.4250	7037.48	18247.9
490	490	154	9	31	35.5083	7648.06	18028.8
491	491	155	10	31	35.5667	7366.09	18083.2
492	492	156	11	31	35.1167	7568.18	17870.0
493	493	157	12	31	35.6750	7407.11	17707.3
494	494	158	13	31	35.8583	6924.34	17963.8
495	495	159	14	31	35.8167	7294.60	17615.1

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
496	496	160	15	31	36.1417	7566.6	17534.0
497	497	161	16	31	36.0333	7095.7	18576.3
498	498	162	17	31	34.3250	7365.4	19117.6
499	499	163	18	31	32.2500	6201.4	19653.6
500	500	164	19	31	31.0667	8261.0	19297.4
501	501	165	20	31	30.1417	8136.5	20002.3
502	502	166	21	31	29.6000	7885.3	20065.3
503	503	167	22	31	29.5167	7795.3	20232.7
504	504	168	23	31	29.1167	8125.3	20265.5
505	505	1	0	31	28.7167	7640.5	18393.6
506	506	2	1	29	28.6917	8428.0	19865.8
507	507	3	2	29	27.9583	8434.6	19879.3
508	508	4	3	29	27.5250	8792.8	20179.1
509	509	5	4	29	27.1167	8972.2	21053.2
510	510	6	5	29	27.1417	9038.8	21193.7
511	511	7	6	29	26.7500	8972.9	21612.9
512	512	8	7	29	26.4667	9772.1	20609.1
513	513	9	8	29	27.1500	9158.4	20038.1
514	514	10	9	29	28.7833	8426.9	19219.5
515	515	11	10	29	30.0750	8096.3	19038.0
516	516	12	11	29	30.7250	8051.6	19013.0
517	517	13	12	29	30.1417	8243.3	19505.9
518	518	14	13	28	29.4500	8260.6	18902.1
519	519	15	14	28	28.5083	7393.6	19493.8
520	520	16	15	28	27.4583	7041.7	20266.0
521	521	17	16	28	26.4667	7422.2	21347.4
522	522	18	17	28	25.8333	8136.1	21783.8
523	523	19	18	28	25.9917	7777.7	21627.7
524	524	20	19	28	26.1750	7529.0	21451.1
525	525	21	20	28	24.0583	8551.9	21723.7
526	526	22	21	28	22.1417	8015.5	22452.8
527	527	23	22	28	20.2833	8757.3	22540.2
528	528	24	23	28	18.3917	9194.8	22902.4
529	529	25	0	28	16.2000	9219.2	23196.4
530	530	26	1	28	14.7833	9052.2	23538.8
531	531	27	2	28	13.1333	9453.3	23894.4
532	532	28	3	28	11.6417	9623.1	24004.8
533	533	29	4	28	10.6083	9709.0	23016.2
534	534	30	5	28	10.1917	9169.0	26096.2
535	535	31	6	28	9.3750	10962.8	25710.9
536	536	32	7	28	10.2667	9616.2	25011.5
537	537	33	8	28	12.3333	10070.2	23582.6
538	538	34	9	28	13.8750	10157.3	22907.1
539	539	35	10	28	15.6083	8659.4	23091.7
540	540	36	11	28	18.1583	9604.5	22459.7
541	541	37	12	28	19.8833	9849.8	21865.4
542	542	38	13	28	19.9167	7728.5	22111.8
543	543	39	14	28	20.5250	8364.5	21260.6
544	544	40	15	28	20.7000	7592.4	21879.3
545	545	41	16	28	20.5250	8153.4	22554.6
546	546	42	17	28	19.8583	8870.3	23361.8
547	547	43	18	28	18.9667	9153.7	23936.0
548	548	44	19	28	18.0917	8512.7	23971.1
549	549	45	20	28	17.3500	8899.1	23828.3
550	550	46	21	28	16.2417	9887.1	24272.4

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OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
551	551	47	22	28	15.3500	8016.0	24474.4
552	552	48	23	28	14.8417	9507.3	23945.0
553	553	49	0	28	14.4083	13811.0	23202.8
554	554	50	1	28	13.7000	7043.1	25840.3
555	555	51	2	28	13.8667	8882.0	24478.8
556	556	52	3	28	13.3167	10331.4	24279.9
557	557	53	4	28	13.2583	11096.0	25139.9
558	558	54	5	28	12.7833	10101.3	25378.6
559	559	55	6	28	12.8500	10648.9	25503.8
560	560	56	7	28	13.4750	10058.8	24205.1
561	561	57	8	28	16.3917	10083.8	22935.1
562	562	58	9	28	18.5750	9160.1	22044.6
563	563	59	10	28	20.3000	9025.6	21315.2
564	564	60	11	28	22.4500	8845.7	20378.8
565	565	61	12	28	24.2417	8815.5	19848.7
566	566	62	13	28	25.0667	7963.5	19149.4
567	567	63	14	28	25.6000	7401.8	18638.2
568	568	64	15	28	26.2583	7690.1	19306.3
569	569	65	16	28	26.0417	6695.8	20662.3
570	570	66	17	28	25.5167	7791.2	20847.1
571	571	67	18	28	25.0833	7228.7	20193.6
572	572	68	19	28	25.4167	7876.5	20243.3
573	573	69	20	28	25.1583	7697.8	20460.3
574	574	70	21	28	24.7083	7985.7	20420.7
575	575	71	22	28	23.8750	8139.4	20456.8
576	576	72	23	28	24.2083	8208.1	20477.0
577	577	73	0	28	25.1333	8461.2	20577.1
578	578	74	1	28	24.3250	8579.3	20418.5
579	579	75	2	28	24.2583	8360.5	20980.4
580	580	76	3	28	24.7500	8547.4	20582.5
581	581	77	4	28	23.7833	8651.5	20956.8
582	582	78	5	28	23.0333	8753.1	21339.9
583	583	79	6	28	23.5417	7741.3	21122.1
584	584	80	7	28	26.0083	8098.3	20497.8
585	585	81	8	28	30.2000	7662.1	19645.0
586	586	82	9	28	34.1417	6818.6	18891.8
587	587	83	10	28	38.0167	6297.6	17954.8
588	588	84	11	28	41.4333	6452.3	17347.3
589	589	85	12	28	44.5083	5697.4	17276.0
590	590	86	13	28	46.7833	5951.5	16745.6
591	591	87	14	28	47.1250	5705.9	16741.6
592	592	88	15	28	46.2250	5624.8	16972.2
593	593	89	16	28	45.5167	6032.1	17228.7
594	594	90	17	28	44.4333	6469.1	17473.4
595	595	91	18	28	43.4167	6004.6	17386.2
596	596	92	19	28	42.4250	6649.3	17892.6
597	597	93	20	28	40.4917	6513.0	17631.4
598	598	94	21	28	38.8333	6706.4	17733.0
599	599	95	22	28	38.2917	6814.3	17285.7
600	600	96	23	28	37.4750	6335.9	17653.2
601	601	97	0	28	37.9083	7050.4	17724.8
602	602	98	1	28	39.3167	6141.6	17803.7
603	603	99	2	28	38.9167	6506.9	17954.7
604	604	100	3	28	38.3667	6681.8	17501.6
605	605	101	4	28	37.7417	6299.6	17804.8

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
606	606	102	5	28	37.0167	6971.77	18169.4
607	607	103	6	28	35.3083	6881.99	18232.4
608	608	104	7	28	35.1667	7118.82	18873.3
609	609	105	8	28	34.7833	7296.57	19351.1
610	610	106	9	28	34.4750	7110.72	19206.4
611	611	107	10	28	33.6750	6789.22	19249.5
612	612	108	11	28	32.9917	7574.45	19310.0
613	613	109	12	28	32.0333	7291.80	19275.5
614	614	110	13	28	31.4333	7279.49	19516.7
615	615	111	14	28	30.9667	7806.71	19767.1
616	616	112	15	28	30.2250	7467.52	19850.7
617	617	113	16	28	29.1833	8155.70	20160.1
618	618	114	17	28	28.0583	8252.82	20552.0
619	619	115	18	28	27.5917	8432.15	20517.7
620	620	116	19	28	27.4167	8817.77	20402.6
621	621	117	20	28	26.9833	8459.84	20732.6
622	622	118	21	28	26.3833	8284.10	20752.8
623	623	119	22	28	25.6583	8679.15	20659.4
624	624	120	23	28	24.8250	8531.71	20768.1
625	625	121	0	28	24.3167	8731.92	21309.7
626	626	122	1	28	23.6333	8837.57	20891.2
627	627	123	2	28	23.2667	8855.88	20904.6
628	628	124	3	28	23.4583	9024.26	21145.4
629	629	125	4	28	23.5033	8540.06	22094.9
630	630	126	5	28	23.7917	8702.33	21945.7
631	631	127	6	28	23.6333	9496.42	21949.8
632	632	128	7	28	24.1667	8932.92	21411.3
633	633	129	8	28	26.4417	8691.77	20495.9
634	634	130	9	28	28.2500	8742.72	19868.4
635	635	131	10	28	30.6333	7951.15	19547.8
636	636	132	11	28	31.9583	7869.91	18302.4
637	637	133	12	28	33.0583	7711.09	17137.9
638	638	134	13	28	33.7667	6999.42	16710.4
639	639	135	14	28	33.7167	6818.38	16910.5
640	640	136	15	28	33.3750	7430.96	16830.6
641	641	137	16	28	32.6417	7129.28	17959.4
642	642	138	17	28	30.5417	7204.08	18896.0
643	643	139	18	28	28.8667	7623.86	18912.9
644	644	140	19	28	28.5417	6988.95	19318.7
645	645	141	20	28	27.7000	7817.18	19367.8
646	646	142	21	28	27.7500	7978.50	19347.4
647	647	143	22	28	26.6333	7900.12	19544.6
648	648	144	23	28	25.9000	8603.75	19451.5
649	649	145	0	28	26.5167	8008.87	19643.6
650	650	146	1	28	26.2500	8429.52	19784.9
651	651	147	2	28	25.3083	8768.30	20160.7
652	652	148	3	28	25.1083	8257.85	19861.0
653	653	149	4	28	24.7583	8485.56	20890.1
654	654	150	5	28	24.2500	8205.04	21087.8
655	655	151	6	28	25.1083	8454.03	20364.3
656	656	152	7	28	27.4500	8604.69	18737.1
657	657	153	8	28	30.2083	8797.59	18549.4
658	658	154	9	28	35.2500	8222.07	18028.3
659	659	155	10	28	36.1500	7734.84	18353.7
660	660	156	11	28	36.1583	8042.42	18441.8

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
661	661	157	12	28	37.6083	7717.07	17644.3
662	662	158	13	28	39.2667	2229.57	16935.8
663	663	159	14	28	40.0750	389.30	16958.9
664	664	160	15	26	39.2667	2346.58	17372.5
665	665	161	16	27	37.4833	4616.11	18500.4
666	666	162	17	27	33.2333	4572.20	19996.8
667	667	163	18	27	30.1333	5070.32	20269.4
668	668	164	19	27	27.5750	5249.93	21024.0
669	669	165	20	27	25.7583	5745.07	21156.4
670	670	166	21	27	24.1167	6090.28	21752.7
671	671	167	22	27	22.9000	6217.08	21898.4
672	672	168	23	32	22.2167	6279.23	21696.9

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
1	1	1	0	30	23.5333	5125.88	19961.8
2	2	2	1	30	23.4000	4519.04	20347.2
3	3	3	2	30	22.9000	4974.72	19947.4
4	4	4	3	30	22.7583	4622.18	19899.7
5	5	5	4	30	22.7417	5308.95	20727.7
6	6	6	5	30	22.3833	5306.81	21639.2
7	7	7	6	30	22.7583	6127.22	20756.3
8	8	8	7	30	23.5250	5352.74	20228.3
9	9	9	8	30	26.8583	5132.31	19221.6
10	10	10	9	30	29.9833	4068.97	18328.6
11	11	11	10	30	32.9417	4667.27	23523.3
12	12	12	11	30	34.7667	4203.81	24886.0
13	13	13	12	30	35.9417	5030.84	24484.7
14	14	14	13	30	37.3167	6083.31	25229.3
15	15	15	14	30	38.2000	3243.02	24517.7
16	16	16	15	30	38.6833	3940.07	24280.6
17	17	17	16	30	38.1417	4287.32	25501.7
18	18	18	17	30	35.7917	4175.67	27051.1
19	19	19	18	30	34.5167	4547.75	27432.9
20	20	20	19	30	34.3500	4371.89	26383.2
21	21	21	20	30	34.5167	4012.50	26524.6
22	22	22	21	30	34.7583	4176.43	26075.3
23	23	23	22	30	34.6833	4564.67	25817.3
24	24	24	23	30	35.2750	4638.37	25518.3
25	25	25	0	30	34.8167	4704.88	25562.2
26	26	26	1	30	34.9917	4796.96	25699.2
27	27	27	2	30	34.6000	4483.82	26164.3
28	28	28	3	30	34.9083	4693.14	26323.6
29	29	29	4	30	35.7167	4805.17	27738.4
30	30	30	5	30	36.0083	4651.08	27971.7
31	31	31	6	30	36.4000	4824.25	26688.8
32	32	32	7	30	37.3417	4813.29	25381.6
33	33	33	8	30	39.3750	4903.22	24294.7
34	34	34	9	30	42.9583	3966.63	20282.2
35	35	35	10	30	49.5167	2902.44	15483.8
36	36	36	11	30	52.3583	3432.06	14200.8
37	37	37	12	30	56.5250	2741.42	14378.6
38	38	38	13	30	58.2333	2461.12	14243.1
39	39	39	14	30	58.4083	2108.97	14745.8
40	40	40	15	30	58.4750	1869.42	14952.5
41	41	41	16	30	57.4083	2147.10	15153.6
42	42	42	17	30	55.1750	3952.17	15560.3
43	43	43	18	30	53.9417	3469.45	16432.4
44	44	44	19	30	53.1416	2837.20	15499.4
45	45	45	20	30	52.3667	2613.68	15679.4
46	46	46	21	30	51.8667	3318.51	15166.5
47	47	47	22	30	51.6500	3306.00	15340.1
48	48	48	23	30	52.2750	3202.33	15120.6
49	49	49	0	30	54.2583	2846.95	15043.5
50	50	50	1	30	53.8917	3021.62	14862.9
51	51	51	2	30	54.1167	2605.00	14738.4
52	52	52	3	30	53.6750	2197.06	14858.3
53	53	53	4	30	50.9167	2675.04	15109.3
54	54	54	5	30	48.9750	2549.29	15783.9
55	55	55	6	30	49.3667	2759.90	15885.5

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
56	56	56	7	30	49.5167	3492.7	16078.6
57	57	57	8	30	49.5500	3550.4	15717.5
58	58	58	9	30	50.6833	2411.7	15895.1
59	59	59	10	30	52.6417	2390.8	15574.8
60	60	60	11	30	54.1583	2343.3	15818.8
61	61	61	12	30	54.5583	2159.7	15595.9
62	62	62	13	30	55.0500	2300.1	15128.4
63	63	63	14	30	54.4750	2350.3	15102.0
64	64	64	15	30	54.8083	3037.6	14944.7
65	65	65	16	30	54.2833	2713.2	15238.9
66	66	66	17	30	53.9333	2605.0	15347.1
67	67	67	18	30	52.3500	3596.8	15276.4
68	68	68	19	30	48.8500	3750.8	15478.1
69	69	69	20	30	45.7667	5053.3	16195.1
70	70	70	21	30	40.6250	6882.1	16344.8
71	71	71	22	30	37.7917	8192.3	17437.4
72	72	72	23	30	35.1333	7989.8	18452.2
73	73	73	0	30	34.3333	6417.5	19839.9
74	74	74	1	30	34.0250	2417.3	21077.0
75	75	75	2	30	33.6250	6276.4	17947.3
76	76	76	3	30	32.9000	6784.0	18132.8
77	77	77	4	30	32.9417	6882.8	18325.2
78	78	78	5	30	32.3667	6900.8	18656.1
79	79	79	6	30	32.1000	6287.5	19587.7
80	80	80	7	30	31.4917	7699.8	19996.1
81	81	81	8	30	30.7417	7388.8	20257.5
82	82	82	9	30	31.2083	7554.0	20792.6
83	83	83	10	30	30.3250	8177.4	20485.0
84	84	84	11	30	30.0000	8885.1	21618.4
85	85	85	12	30	29.7000	6721.3	21723.2
86	86	86	13	30	29.5667	7764.9	20858.0
87	87	87	14	30	29.5167	7231.6	21089.9
88	88	88	15	30	29.4167	7341.6	21296.0
89	89	89	16	30	28.9750	8006.8	21314.2
90	90	90	17	30	28.6833	8346.5	21526.9
91	91	91	18	30	27.5833	8460.7	21663.0
92	92	92	19	30	26.2417	8300.5	22004.5
93	93	93	20	30	24.8167	7892.3	22666.3
94	94	94	21	30	24.6417	8573.9	22350.3
95	95	95	22	30	23.9000	8236.6	22802.3
96	96	96	23	30	23.8083	8799.0	22662.0
97	97	97	0	30	23.1250	8885.3	22776.1
98	98	98	1	30	22.5417	9479.4	22789.3
99	99	99	2	30	22.6167	8642.8	22997.6
100	100	100	3	30	21.9917	10114.4	23848.6
101	101	101	4	30	21.5250	9095.3	25488.8
102	102	102	5	30	21.3583	9770.9	25780.4
103	103	103	6	30	21.7167	10281.4	26167.8
104	104	104	7	30	22.5167	8095.0	26832.4
105	105	105	8	30	22.8583	6999.5	25884.6
106	106	106	9	30	23.0500	8465.9	24690.8
107	107	107	10	30	24.2167	9111.3	23430.0
108	108	108	11	30	25.1917	8738.3	23754.1
109	109	109	12	30	26.0750	9079.1	23235.9
110	110	110	13	30	25.6667	8804.0	23515.2

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
111	111	111	14	30	24.5583	8627.3	23495.1
112	112	112	15	30	23.0667	8509.0	24248.8
113	113	113	16	30	22.7083	8839.4	25556.4
114	114	114	17	30	22.4583	7958.7	25157.2
115	115	115	18	30	22.5583	8834.7	25015.9
116	116	116	19	30	21.3333	9205.9	25082.2
117	117	117	20	30	20.8333	8864.8	22987.9
118	118	118	21	30	19.6750	9171.2	24924.1
119	119	119	22	30	19.0667	9458.8	25080.3
120	120	120	23	30	18.6750	10045.8	24581.6
121	121	121	0	30	18.2917	9564.6	25390.8
122	122	122	1	30	17.1583	8975.2	25269.4
123	123	123	2	30	15.9917	10174.4	25253.6
124	124	124	3	30	15.1000	10675.0	25636.7
125	125	125	4	30	14.3000	10402.2	27141.5
126	126	126	5	30	13.6917	11828.6	28026.4
127	127	127	6	30	13.5417	11745.8	27877.2
128	128	128	7	30	14.3750	10421.0	27421.5
129	129	129	8	30	15.7000	10603.1	26732.3
130	130	130	9	30	17.2083	9763.1	25949.6
131	131	131	10	30	18.8083	9112.5	24516.8
132	132	132	11	30	20.6250	9346.5	23385.8
133	133	133	12	30	21.5417	9992.2	22669.8
134	134	134	13	30	22.4833	9050.5	22056.7
135	135	135	14	30	23.4417	8200.4	22455.5
136	136	136	15	30	23.8167	9139.1	23151.5
137	137	137	16	30	22.9250	8958.3	24263.1
138	138	138	17	30	22.0583	8070.2	24922.3
139	139	139	18	30	20.9583	8913.6	24451.9
140	140	140	19	30	20.0333	8550.4	24587.7
141	141	141	20	30	19.1333	8885.5	24670.5
142	142	142	21	30	18.2750	9446.8	24714.6
143	143	143	22	30	17.4500	9647.5	24277.7
144	144	144	23	30	16.8750	10225.1	24228.0
145	145	1	0	30	16.5000	8347.7	24521.5
146	146	2	1	30	15.7917	10024.3	24368.9
147	147	3	2	30	15.6417	9168.3	24563.7
148	148	4	3	30	15.5583	10069.5	23781.9
149	149	5	4	30	15.9667	10938.3	25311.1
150	150	6	5	30	16.3083	10275.3	25846.8
151	151	7	6	30	17.3500	11946.4	24738.6
152	152	8	7	30	18.6167	11365.6	25381.1
153	153	9	8	30	20.5667	10515.4	24483.3
154	154	10	9	30	24.3167	8721.0	24029.5
155	155	11	10	30	26.0083	9135.9	22728.6
156	156	12	11	30	27.8000	8807.0	21614.4
157	157	13	12	30	29.9333	9404.5	20676.4
158	158	14	13	30	31.7333	8788.6	20157.2
159	159	15	14	30	31.8250	7460.2	19956.0
160	160	16	15	30	32.3417	6581.0	20429.4
161	161	17	16	30	32.7417	7819.5	21052.1
162	162	18	17	30	32.8667	8306.5	21816.9
163	163	19	18	30	31.9500	8155.8	21985.1
164	164	20	19	30	31.6083	8397.9	21775.6
165	165	21	20	30	31.5083	8571.2	22049.1

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
166	166	22	21	30	31.3000	8809.35	21582.2
167	167	23	22	30	30.1083	8897.92	21878.7
168	168	24	23	30	29.9417	9283.42	21805.4
169	169	25	0	30	29.0250	9192.47	21626.7
170	170	26	1	30	28.8750	9572.08	21847.3
171	171	27	2	30	27.8583	9387.10	21878.7
172	172	28	3	30	27.1000	9812.63	22387.5
173	173	29	4	30	26.5333	9870.84	23008.2
174	174	30	5	30	26.8667	9205.11	23600.6
175	175	31	6	30	26.9167	9419.75	20517.4
176	176	32	7	30	29.4500	9657.92	21313.9
177	177	33	8	30	32.5500	8628.54	20027.2
178	178	34	9	30	34.5750	8643.46	19308.8
179	179	35	10	30	36.5000	8215.02	18793.6
180	180	36	11	30	39.2250	8083.17	18685.8
181	181	37	12	30	38.3667	7120.60	18273.5
182	182	38	13	30	38.6917	7207.63	18140.7
183	183	39	14	30	39.2333	6731.50	17598.1
184	184	40	15	30	39.5750	6507.93	18219.7
185	185	41	16	30	39.7083	6828.63	19126.3
186	186	42	17	30	41.0750	6779.59	20115.1
187	187	43	18	30	38.4417	6783.77	20261.5
188	188	44	19	30	37.5500	6438.74	20334.8
189	189	45	20	30	37.1500	7295.19	20053.7
190	190	46	21	30	35.8667	7179.70	20230.8
191	191	47	22	30	35.3000	6741.32	20536.3
192	192	48	23	30	35.2917	7269.02	19966.8
193	193	49	0	30	35.0750	7429.18	20083.4
194	194	50	1	30	35.6000	7610.08	20240.0
195	195	51	2	30	34.8000	6762.18	20755.0
196	196	52	3	30	34.5250	6560.13	20980.2
197	197	53	4	30	34.9417	7762.25	21669.9
198	198	54	5	30	33.1417	7858.82	21843.4
199	199	55	6	30	33.4083	7547.29	20439.1
200	200	56	7	30	35.5333	7860.62	20052.4
201	201	57	8	30	37.4333	8066.92	19157.9
202	202	58	9	30	39.1333	7265.73	18968.5
203	203	59	10	30	40.8833	6880.22	18416.9
204	204	60	11	30	41.7000	7153.77	18814.0
205	205	61	12	30	43.7083	6599.96	17964.7
206	206	62	13	30	45.5667	6130.33	17574.3
207	207	63	14	30	46.5667	5852.21	16991.4
208	208	64	15	30	47.2250	6250.92	17204.9
209	209	65	16	30	47.1917	6209.41	18348.5
210	210	66	17	30	45.5000	6670.07	18936.3
211	211	67	18	30	43.5917	6619.52	18760.0
212	212	68	19	30	42.5833	6899.10	19034.2
213	213	69	20	30	41.4083	7521.41	18829.7
214	214	70	21	30	41.1333	6738.92	18614.4
215	215	71	22	30	41.1250	7324.87	18826.3
216	216	72	23	30	41.0167	7303.73	18726.7
217	217	73	0	30	40.3083	7313.57	18688.1
218	218	74	1	30	40.0417	7208.42	18859.0
219	219	75	2	30	39.8000	7457.77	19038.7
220	220	76	3	30	40.1917	7236.82	18953.2

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
221	221	77	4	30	40.2000	7406.3	19261.2
222	222	78	5	30	39.5417	7879.2	19755.5
223	223	79	6	30	39.9667	7078.4	20142.2
224	224	80	7	30	42.7083	6807.9	19113.3
225	225	81	8	30	46.9750	5974.9	18500.3
226	226	82	9	30	51.0917	5748.1	17574.2
227	227	83	10	30	56.2166	5398.9	17049.7
228	228	84	11	30	59.3083	4801.1	16493.6
229	229	85	12	30	61.3416	5128.9	15627.0
230	230	86	13	30	62.4500	4800.7	15886.3
231	231	87	14	30	63.1750	4835.2	15540.8
232	232	88	15	30	63.4167	4287.6	15912.1
233	233	89	16	30	61.6500	5026.4	16695.9
234	234	90	17	30	58.9333	4990.8	16575.9
235	235	91	18	30	56.7167	5576.9	17182.4
236	236	92	19	30	54.9583	9336.3	16126.3
237	237	93	20	30	48.8250	5169.3	19185.8
238	238	94	21	30	45.1500	7233.5	19799.3
239	239	95	22	30	42.5583	8693.7	20130.8
240	240	96	23	30	40.5667	10957.4	21100.3
241	241	97	0	30	38.7083	13517.7	21899.3
242	242	98	1	30	37.0500	2987.5	24507.2
243	243	99	2	30	36.1250	3633.4	23553.7
244	244	100	3	30	35.3417	6216.5	22657.2
245	245	101	4	30	35.2417	6956.7	22310.9
246	246	102	5	30	34.6000	7360.3	22279.5
247	247	103	6	30	34.3833	17496.5	21692.4
248	248	104	7	30	35.2250	4945.8	25290.7
249	249	105	8	30	36.0167	3632.9	25252.5
250	250	106	9	30	35.5667	5451.0	24638.5
251	251	107	10	30	36.2833	6055.2	23794.4
252	252	108	11	30	37.1833	6097.6	24108.8
253	253	109	12	30	36.7417	842.6	25258.4
254	254	110	13	30	37.2750	3530.7	22494.0
255	255	111	14	30	37.9000	11834.3	20055.4
256	256	112	15	30	38.2000	9635.0	20609.9
257	257	113	16	30	38.5250	10582.1	21174.4
258	258	114	17	30	38.3583	7262.6	22244.2
259	259	115	18	30	38.7167	8136.5	21494.9
260	260	116	19	30	38.2750	7963.7	21048.8
261	261	117	20	30	37.8917	9545.8	20499.3
262	262	118	21	30	37.8333	9689.7	20281.7
263	263	119	22	30	37.1500	9785.0	20325.3
264	264	120	23	30	36.4333	9785.7	20165.6
265	265	121	0	30	36.3333	9816.6	20302.7
266	266	122	1	30	36.0833	9956.8	20170.8
267	267	123	2	30	35.3917	9968.0	20491.9
268	268	124	3	30	35.0417	10094.1	20766.0
269	269	125	4	30	34.8833	9924.4	21681.3
270	270	126	5	30	34.9083	9093.6	21877.9
271	271	127	6	30	35.2583	9775.0	21218.2
272	272	128	7	30	35.9333	10164.4	20367.6
273	273	129	8	30	37.1083	9238.4	19481.2
274	274	130	9	30	40.4750	8086.7	18612.9
275	275	131	10	30	43.8000	7275.7	17610.0

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
276	276	132	11	30	46.7167	7381.8	17098.5
277	277	133	12	30	50.4417	7095.1	16306.9
278	278	134	13	30	53.3500	5606.4	15980.0
279	279	135	14	30	53.7500	5760.1	15129.2
280	280	136	15	30	54.8500	4852.3	15130.2
281	281	137	16	30	55.5667	5056.0	15925.2
282	282	138	17	30	52.1667	6389.6	17148.4
283	283	139	18	30	49.4750	6867.0	16867.6
284	284	140	19	30	48.3000	7143.7	16780.7
285	285	141	20	30	46.0417	7338.4	17088.8
286	286	142	21	30	45.7750	7029.6	17124.3
287	287	143	22	30	45.5083	7224.7	16948.8
288	288	144	23	30	44.2167	7477.6	16801.7
289	289	145	0	30	35.9667	7672.0	16971.0
290	290	146	1	30	42.4750	6766.7	16867.7
291	291	147	2	30	42.4833	7817.6	16699.5
292	292	148	3	30	42.5917	7496.1	16945.1
293	293	149	4	30	41.7417	7780.3	18330.1
294	294	150	5	30	40.9000	7538.6	18899.7
295	295	151	6	30	42.1917	8218.9	17389.6
296	296	152	7	30	43.7750	7530.8	17125.8
297	297	153	8	30	46.3333	7628.8	16872.6
298	298	154	9	30	51.5583	6384.8	15555.8
299	299	155	10	30	54.9417	5770.5	15583.7
300	300	156	11	30	58.0917	4330.8	15295.4
301	301	157	12	30	62.6667	5554.1	14210.6
302	302	158	13	30	65.6583	3787.3	14084.4
303	303	159	14	30	68.3917	4774.1	13532.1
304	304	160	15	30	69.4667	3939.1	14097.8
305	305	161	16	30	68.7083	3847.6	14805.1
306	306	162	17	30	63.5833	4880.8	15136.8
307	307	163	18	30	62.7333	4615.0	15030.9
308	308	164	19	30	63.1667	4980.5	15190.4
309	309	165	20	30	61.8000	5136.7	15200.5
310	310	166	21	30	61.1500	5736.0	14941.6
311	311	167	22	30	61.6083	5039.3	14637.0
312	312	168	23	30	60.4083	5174.8	14680.5
313	313	1	0	30	55.9000	5075.0	17189.6
314	314	2	1	29	47.7333	7558.2	16947.5
315	315	3	2	29	40.8167	16149.6	17643.6
316	316	4	3	29	38.7167	8227.8	18129.9
317	317	5	4	29	38.2333	9091.4	19804.5
318	318	6	5	29	37.3667	8670.0	20490.2
319	319	7	6	29	35.4750	9048.8	20140.1
320	320	8	7	29	34.7250	9914.9	20192.3
321	321	9	8	29	34.8583	6035.6	19388.9
322	322	10	9	29	36.8417	6684.0	18418.8
323	323	11	10	29	36.2417	6106.8	19535.7
324	324	12	11	29	36.0917	3060.2	19401.0
325	325	13	12	29	35.8750	6309.2	19252.9
326	326	14	13	29	35.9833	7302.8	19049.9
327	327	15	14	29	35.7000	6833.8	18735.2
328	328	16	15	29	35.1917	6828.0	19505.3
329	329	17	16	29	34.7000	7157.9	20215.6
330	330	18	17	29	34.4250	7212.0	20297.9

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
331	331	19	18	29	33.6083	7308.14	19923.6
332	332	20	19	29	32.8417	7138.57	19725.8
333	333	21	20	29	32.5083	7006.99	19766.3
334	334	22	21	29	32.3667	7295.93	19990.2
335	335	23	22	29	31.6417	7283.17	19564.5
336	336	24	23	29	31.0667	7054.67	19733.9
337	337	25	0	29	30.8083	7047.79	19596.7
338	338	26	1	29	30.1917	6945.62	19811.0
339	339	27	2	29	29.2917	7338.86	19963.3
340	340	28	3	29	27.8000	7250.53	20022.5
341	341	29	4	29	27.7917	7691.60	21154.2
342	342	30	5	29	28.0417	7437.94	22123.6
343	343	31	6	29	28.4667	8321.05	20355.9
344	344	32	7	29	32.5917	8505.57	19601.6
345	345	33	8	29	36.3250	7540.07	19016.2
346	346	34	9	29	38.1667	7485.76	18018.3
347	347	35	10	29	41.3583	7187.26	17836.3
348	348	36	11	29	43.9750	7145.15	17218.0
349	349	37	12	29	47.2750	5563.45	16321.3
350	350	38	13	29	52.0333	4842.12	15890.7
351	351	39	14	29	53.6750	4713.88	15382.0
352	352	40	15	29	53.2083	5105.13	15418.4
353	353	41	16	29	53.7917	4352.88	16045.8
354	354	42	17	29	51.6917	4977.69	17190.3
355	355	43	18	29	49.6583	4702.15	17068.4
356	356	44	19	29	47.6000	4725.26	17267.2
357	357	45	20	29	45.6583	5247.53	17224.3
358	358	46	21	29	44.6667	5353.20	17281.3
359	359	47	22	29	42.8000	4826.20	17386.0
360	360	48	23	29	41.4333	5224.34	17836.5
361	361	49	0	29	40.4500	5159.69	17527.0
362	362	50	1	29	39.5000	5781.89	17702.6
363	363	51	2	29	39.1167	5208.47	17560.0
364	364	52	3	29	38.4917	5481.61	18027.6
365	365	53	4	29	37.7417	6069.10	19428.7
366	366	54	5	29	37.9750	5882.62	19401.8
367	367	55	6	29	39.3833	5853.13	17892.9
368	368	56	7	29	44.2667	7164.85	16875.3
369	369	57	8	29	49.3083	6227.36	15591.0
370	370	58	9	29	55.1750	4448.52	14727.4
371	371	59	10	29	60.1667	3689.20	14115.7
372	372	60	11	29	63.9500	3255.85	13801.6
373	373	61	12	29	66.5833	3572.39	13313.4
374	374	62	13	29	69.7333	3703.74	12967.3
375	375	63	14	29	71.9667	3944.02	12396.6
376	376	64	15	29	72.5583	3384.15	13019.1
377	377	65	16	29	73.7583	3495.85	13633.9
378	378	66	17	29	72.1250	3807.89	13612.9
379	379	67	18	29	71.0250	3727.04	13425.4
380	380	68	19	29	70.7833	3374.64	13274.8
381	381	69	20	29	71.8667	3627.05	12554.1
382	382	70	21	29	72.7833	2970.36	12779.7
383	383	71	22	29	72.2333	3528.73	12721.2
384	384	72	23	29	70.4250	4050.37	12732.3
385	385	73	0	29	54.4250	5407.84	15080.3

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
386	386	74	1	29	47.3167	4460.47	15431.6
387	387	75	2	29	40.5250	4953.88	16294.6
388	388	76	3	29	37.3583	5642.72	16522.9
389	389	77	4	29	35.9333	6043.97	16979.3
390	390	78	5	29	34.7917	5350.55	17305.6
391	391	79	6	29	32.8167	5221.87	18459.1
392	392	80	7	29	31.8833	6069.13	18736.3
393	393	81	8	29	31.7750	6321.58	18845.6
394	394	82	9	29	31.7917	6318.05	18547.0
395	395	83	10	29	32.4750	6051.28	18651.8
396	396	84	11	29	33.3333	6141.77	18746.6
397	397	85	12	29	32.5750	6604.21	18797.6
398	398	86	13	29	32.1250	6553.13	19045.7
399	399	87	14	29	32.1083	6239.27	18970.9
400	400	88	15	29	32.6333	6827.62	18659.1
401	401	89	16	29	32.1417	6851.79	19048.3
402	402	90	17	29	31.2250	7123.22	19790.4
403	403	91	18	29	30.4333	7405.67	19490.1
404	404	92	19	29	29.8500	7324.11	19731.3
405	405	93	20	29	29.3583	7577.17	19638.6
406	406	94	21	29	28.8750	7444.66	19697.7
407	407	95	22	29	28.2417	7317.57	20128.1
408	408	96	23	29	27.8500	7602.19	20494.3
409	409	97	0	29	27.7750	7914.90	19679.6
410	410	98	1	29	27.5583	7852.57	19863.7
411	411	99	2	29	27.4250	8045.27	20153.7
412	412	100	3	29	27.4333	8192.02	20127.3
413	413	101	4	29	27.4750	7929.38	19957.3
414	414	102	5	29	27.2833	8072.43	20026.5
415	415	103	6	29	26.9000	7472.98	20150.2
416	416	104	7	29	28.5500	7624.07	19614.9
417	417	105	8	29	28.8250	7868.18	19862.6
418	418	106	9	29	30.3583	7227.31	19337.9
419	419	107	10	29	32.1667	7206.66	19145.2
420	420	108	11	29	34.5333	6611.14	17915.1
421	421	109	12	29	36.0167	5985.60	17486.0
422	422	110	13	29	37.2333	5563.66	16971.2
423	423	111	14	29	39.1250	5830.21	16518.8
424	424	112	15	29	39.3500	5367.08	17309.2
425	425	113	16	29	39.4083	6035.00	17603.8
426	426	114	17	29	39.7083	6355.03	17824.5
427	427	115	18	29	39.4417	6032.68	17625.8
428	428	116	19	29	39.4250	6201.06	17342.1
429	429	117	20	29	39.3333	6013.55	17853.8
430	430	118	21	29	39.2667	5843.74	18021.7
431	431	119	22	29	38.5083	6047.40	17917.5
432	432	120	23	29	38.0833	6801.32	17697.2
433	433	121	0	29	37.8667	6233.46	17545.6
434	434	122	1	29	37.7917	6188.47	17659.3
435	435	123	2	29	35.6417	6675.84	17970.7
436	436	124	3	29	33.5333	7073.56	18384.6
437	437	125	4	29	33.5083	7122.68	19957.8
438	438	126	5	29	34.1500	7146.88	20125.5
439	439	127	6	29	35.1250	6891.67	19727.0
440	440	128	7	29	34.8333	6808.61	19442.4

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OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
441	441	129	8	29	34.7500	7451.92	19146.1
442	442	130	9	29	35.0333	7222.49	18902.3
443	443	131	10	29	35.9667	6863.37	19134.6
444	444	132	11	29	37.0167	7313.18	19394.2
445	445	133	12	29	39.1083	7559.61	19133.4
446	446	134	13	29	40.4000	6154.26	13476.7
447	447	135	14	29	40.8167	5852.31	18806.6
448	448	136	15	29	40.3333	6352.07	18918.9
449	449	137	16	29	39.3917	6346.74	19717.0
450	450	138	17	29	38.4000	6183.97	20677.8
451	451	139	18	29	36.3500	6872.67	21255.6
452	452	140	19	29	35.9750	6865.77	20498.0
453	453	141	20	29	36.0833	6427.32	19970.1
454	454	142	21	29	35.9000	6723.79	20463.1
455	455	143	22	29	34.5083	7246.38	20711.1
456	456	144	23	29	33.3833	7134.47	20848.3
457	457	145	0	29	32.8083	7150.07	20812.0
458	458	146	1	29	32.5917	7112.38	20747.3
459	459	147	2	29	32.2833	7423.83	21106.6
460	460	148	3	29	30.9000	7170.07	21912.7
461	461	149	4	29	29.9583	7951.98	23127.1
462	462	150	5	29	29.6000	8346.63	23244.2
463	463	151	6	29	27.4667	8514.02	23453.0
464	464	152	7	29	27.8250	7469.08	22714.2
465	465	153	8	29	28.2583	7568.43	21046.9
466	466	154	9	29	29.2917	7130.66	19907.7
467	467	155	10	29	30.6667	7703.27	20085.8
468	468	156	11	29	33.3583	7308.42	19576.3
469	469	157	12	29	32.9167	7460.39	19102.5
470	470	158	13	29	33.5417	6726.42	13832.1
471	471	159	14	29	34.9667	6492.25	18418.1
472	472	160	15	29	35.3083	6642.69	18650.1
473	473	161	16	29	34.8667	7013.34	19921.3
474	474	162	17	29	34.1333	7051.97	20930.4
475	475	163	18	29	33.3750	7209.41	20951.7
476	476	164	19	29	32.6333	7298.95	20854.7
477	477	165	20	29	31.8583	7208.74	20924.2
478	478	166	21	29	31.5167	7499.41	21032.2
479	479	167	22	29	30.8000	7571.42	20680.7
480	480	168	23	29	30.1583	7614.67	20673.1
481	481	1	0	29	29.5167	7127.35	21375.1
482	482	2	1	30	28.9264	7405.40	19427.5
483	483	3	2	30	27.8939	8119.23	21327.9
484	484	4	3	30	27.2745	8373.98	21731.1
485	485	5	4	30	26.5312	9066.16	22634.5
486	486	6	5	30	26.1635	7375.02	23624.1
487	487	7	6	30	26.7553	8259.81	22317.5
488	488	8	7	30	28.0842	7721.75	21135.2
489	489	9	8	30	29.8070	7341.00	20383.1
490	490	10	9	30	31.2339	7197.52	19739.8
491	491	11	10	30	33.0695	6826.26	19710.6
492	492	12	11	30	37.1417	6915.39	18683.4
493	493	13	12	30	37.3035	6725.59	18301.0
494	494	14	13	30	37.8089	6451.14	17387.8
495	495	15	14	30	36.6541	6091.41	17077.0

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
496	496	16	15	30	39.3710	5327.69	17804.9
497	497	17	16	30	39.8309	5835.28	18338.3
498	498	18	17	30	39.4833	6413.05	19683.3
499	499	19	18	30	39.1958	6408.47	20924.9
500	500	20	19	30	37.8330	6162.83	19777.4
501	501	21	20	30	37.6888	6346.39	19919.4
502	502	22	21	30	34.8231	6896.03	18498.5
503	503	23	22	30	33.8974	7028.83	17941.8
504	504	24	23	30	33.7833	7076.44	19819.8
505	505	25	0	30	32.7986	7084.15	19915.0
506	506	26	1	30	32.3999	7311.96	20155.2
507	507	27	2	30	31.7000	7194.44	20132.4
508	508	28	3	30	30.6917	7396.11	20272.2
509	509	29	4	30	30.3236	7387.43	19954.5
510	510	30	5	30	30.5186	7610.64	20137.8
511	511	31	6	30	31.4411	6936.82	20979.3
512	512	32	7	30	34.4402	8664.61	18628.5
513	513	33	8	29	38.9533	5215.43	19334.6
514	514	34	9	29	44.0833	4559.60	18161.9
515	515	35	10	29	46.9083	5589.13	17099.5
516	516	36	11	29	50.5333	5645.83	16570.4
517	517	37	12	29	51.3667	5268.51	16345.2
518	518	38	13	29	53.4750	3888.27	15432.6
519	519	39	14	29	54.4750	4380.13	14877.0
520	520	40	15	29	54.8000	3869.39	15520.0
521	521	41	16	29	54.7583	4584.46	15259.3
522	522	42	17	29	53.3583	5426.33	16361.9
523	523	43	18	29	50.7917	4914.53	17175.4
524	524	44	19	29	48.5833	4843.80	17241.7
525	525	45	20	29	47.0500	4885.16	17330.2
526	526	46	21	29	46.0833	5029.06	17788.5
527	527	47	22	29	43.9583	5517.38	17852.3
528	528	48	23	29	42.5000	5455.90	17496.8
529	529	49	0	29	41.8583	5700.42	17795.5
530	530	50	1	29	40.1833	5881.37	18182.3
531	531	51	2	29	39.9333	5894.09	18385.1
532	532	52	3	29	38.7083	6127.23	19043.7
533	533	53	4	29	36.9917	6508.44	20109.6
534	534	54	5	29	37.0250	6729.20	20136.1
535	535	55	6	29	37.0250	6681.48	18729.5
536	536	56	7	29	41.8500	6810.36	17171.0
537	537	57	8	29	47.8833	5457.19	16373.4
538	538	58	9	29	52.1167	5374.90	15860.4
539	539	59	10	29	55.8250	4759.57	15348.1
540	540	60	11	29	59.2916	5091.18	14933.4
541	541	61	12	29	60.2750	5369.72	14305.8
542	542	62	13	29	61.3167	3855.53	14454.0
543	543	63	14	29	62.5167	3616.57	14393.4
544	544	64	15	29	63.0500	3720.26	14234.2
545	545	65	16	29	62.3500	3818.41	14463.1
546	546	66	17	29	59.4250	4584.32	15304.2
547	547	67	18	29	56.2500	4437.05	15802.6
548	548	68	19	29	54.6083	4403.57	15446.4
549	549	69	20	29	53.2250	4543.90	15564.8
550	550	70	21	29	52.5417	3866.88	15579.4

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
551	551	71	22	29	50.9083	4424.97	15570.4
552	552	72	23	29	49.3417	5151.13	16077.0
553	553	73	0	29	50.8250	4664.56	15662.6
554	554	74	1	29	50.4833	5092.27	15796.7
555	555	75	2	29	49.6500	5321.74	15901.8
556	556	76	3	29	48.8250	5241.63	15953.5
557	557	77	4	29	47.6917	6523.01	16256.6
558	558	78	5	29	48.2667	5169.53	16528.3
559	559	79	6	29	46.4750	5997.55	15954.8
560	560	80	7	29	53.5333	6512.81	15787.6
561	561	81	8	29	56.5583	4436.87	16075.9
562	562	82	9	29	60.0833	4570.39	14876.3
563	563	83	10	29	64.2500	4154.17	14670.2
564	564	84	11	29	68.0000	4033.10	13968.0
565	565	85	12	29	69.0583	3959.05	13802.4
566	566	86	13	29	69.6833	4080.41	13528.6
567	567	87	14	29	69.7583	4361.74	13563.1
568	568	88	15	29	69.0417	4098.86	13345.6
569	569	89	16	29	68.3417	4256.36	13459.0
570	570	90	17	29	66.9667	4081.72	13793.3
571	571	91	18	29	65.4750	3891.63	14179.0
572	572	92	19	29	61.5000	3810.75	14012.9
573	573	93	20	29	58.9500	4167.06	14271.2
574	574	94	21	29	56.9917	3953.75	14025.3
575	575	95	22	29	55.9250	3970.40	14562.4
576	576	96	23	29	55.0000	3990.57	14547.8
577	577	97	0	29	50.6000	4196.02	15126.9
578	578	98	1	29	50.8083	4211.87	14724.6
579	579	99	2	29	49.8667	3937.82	15067.2
580	580	100	3	29	48.9250	4676.59	15029.9
581	581	101	4	29	48.7083	4982.60	15015.6
582	582	102	5	29	48.5083	4774.31	15268.8
583	583	103	6	29	50.1833	4507.92	14865.8
584	584	104	7	29	54.6083	4268.33	14794.5
585	585	105	8	29	60.6083	4475.04	14585.6
586	586	106	9	29	65.4667	3993.41	14193.8
587	587	107	10	29	68.5417	4102.19	13618.1
588	588	108	11	29	70.8166	4293.34	13397.8
589	589	109	12	29	71.4583	3918.88	13154.5
590	590	110	13	29	71.7083	3948.48	13093.8
591	591	111	14	29	72.6500	3952.95	12943.7
592	592	112	15	29	72.7833	4021.38	12990.0
593	593	113	16	29	72.3750	4312.84	13007.9
594	594	114	17	29	70.2000	3982.88	13053.8
595	595	115	18	29	68.1583	4017.37	13102.6
596	596	116	19	29	67.0500	3855.19	12670.4
597	597	117	20	29	63.9083	4100.89	13239.8
598	598	118	21	29	61.9000	4196.12	13620.0
599	599	119	22	29	62.1750	3910.82	13549.0
600	600	120	23	29	60.2667	4206.97	13294.9
601	601	121	0	29	58.8500	4008.66	13360.3
602	602	122	1	29	57.1417	3944.43	13753.4
603	603	123	2	29	55.9583	4222.58	13606.3
604	604	124	3	29	55.5750	4268.70	14348.6
605	605	125	4	29	55.4250	4245.25	14900.7

SAS

OBS	HR	HRMO	HRDA	MIN	TEMP	STM1	STM2
606	606	126	5	29	56.6083	4120.60	14849.6
607	607	127	6	29	56.8083	3786.17	14124.4
608	608	128	7	29	60.3000	4304.93	13196.3
609	609	129	8	29	65.0583	3846.55	10452.3
610	610	130	9	29	69.2667	3676.42	9917.3
611	611	131	10	29	71.5250	4225.32	9642.9
612	612	132	11	29	71.2250	3917.06	9977.6
613	613	133	12	29	70.8750	4126.56	10393.5
614	614	134	13	29	68.9083	3902.77	12725.8
615	615	135	14	29	69.7000	3589.90	12098.9
616	616	136	15	29	69.6917	3709.07	12122.2
617	617	137	16	29	68.8583	3919.10	11989.0
618	618	138	17	29	69.2000	3851.78	12374.0
619	619	139	18	29	68.9416	3623.63	12234.6
620	620	140	19	29	68.7583	3650.55	12009.9
621	621	141	20	29	68.0250	3358.21	12230.3
622	622	142	21	29	66.7167	3556.79	11907.5
623	623	143	22	29	65.4583	3863.67	11821.1
624	624	144	23	29	65.2833	4104.97	11623.3
625	625	145	0	29	64.9833	3776.54	11696.6
626	626	146	1	29	65.6500	3814.21	11614.1
627	627	147	2	29	64.3667	3804.02	11530.8
628	628	148	3	29	61.6750	3964.66	11864.4
629	629	149	4	29	59.2833	3853.34	13582.8
630	630	150	5	29	58.5083	4007.85	13684.8
631	631	151	6	29	61.0750	3729.34	12695.7
632	632	152	7	29	64.4417	3699.80	11744.6
633	633	153	8	29	68.9250	3615.68	9508.5
634	634	154	9	29	73.4083	3392.27	9469.5
635	635	155	10	29	72.0750	3706.98	9476.5
636	636	156	11	29	72.7500	4119.12	10683.6
637	637	157	12	29	74.5083	3303.74	11222.3
638	638	158	13	29	74.6750	4155.75	11020.8
639	639	159	14	29	74.0333	4188.38	11086.3
640	640	160	15	29	72.6583	3593.89	11304.6
641	641	161	16	29	71.1916	3732.80	11338.6
642	642	162	17	29	69.5250	3780.63	11375.7
643	643	163	18	29	68.6667	3791.13	11474.1
644	644	164	19	29	69.4583	3502.12	11348.8
645	645	165	20	29	68.2333	3743.41	11244.7
646	646	166	21	29	67.6333	3812.30	11039.9
647	647	167	22	29	67.2917	3791.96	11057.7
648	648	168	23	29	65.6750	4115.99	11197.0

APPENDIX C: Sample *Forecast Pro* Output for Beta Line, March 1989

```
FORECAST PRO Version 1.12Fri Nov 30 15:35:00 1990

Expert data exploration of dependent variable FCS0389

BASIC STATISTICS
Number of observations: 468
Standard deviation: 4227.444463
Minimum: 12380.490234  Maximum: 33036.289063
Trend-cycle 85.15%  Seasonal 1.14%  Irregular 13.72%

BASIC PROPERTIES
A power transformation may help - try the logarithm.
Correlational structure is strong.
Series is stationary.
Strong explanatory variables:
FCH0389

Data appear to be homogeneous.

RECOMMENDED METHOD: DYNAMIC REGRESSION.

Historical fit of dynamic regression model
Dependent variable: FCS0389
R-square: 0.744
Adjusted R-square: 0.743
Standard forecast error: 2143.137379
F statistic: 677.483 (1.000)
Durbin-Watson: 0.432
Ljung-Box: 1416.629 (1.000)
Standardized AIC: 2147.711795
Standardized BIC: 2166.834274 ** BEST

Variable          Coefficient    Standard error    T-stat        Prob
FCH0389            292.955882        7.958627      36.810        1.000
_CONST           11369.638201      280.001173      40.606        1.000

Model dynamics diagnostics
AUTO[-1] error term                   Chisq(1)=285.473    P=1.000 **
AUTO[-2] error term                   Chisq(1)=200.847    P=1.000 **
AUTO[-3] error term                   Chisq(1)=167.695    P=1.000 **
AUTO[-4] error term                   Chisq(1)=141.488    P=1.000 **
AUTO[-5] error term                   Chisq(1)=111.597    P=1.000 **
AUTO[-6] error term                   Chisq(1)=102.167    P=1.000 **
AUTO[-7] error term                   Chisq(1)=99.081     P=1.000 **
AUTO[-8] error term                   Chisq(1)=77.779     P=1.000 **
AUTO[-9] error term                   Chisq(1)=56.428     P=1.000 **
AUTO[-10] error term                  Chisq(1)=50.027     P=1.000 **
AUTO[-11] error term                  Chisq(1)=58.578     P=1.000 **
AUTO[-12] error term                  Chisq(1)=46.814     P=1.000 **
AUTO[-24] error term                  Chisq(1)=1.820      P=0.823
FCS0389[-1]                           Chisq(1)=253.112    P=1.000 **
FCS0389[-2]                           Chisq(1)=155.050    P=1.000 **
FCS0389[-3]                           Chisq(1)=114.559    P=1.000 **
FCS0389[-4]                           Chisq(1)=91.590     P=1.000 **
FCS0389[-5]                           Chisq(1)=66.486     P=1.000 **
FCS0389[-6]                           Chisq(1)=58.574     P=1.000 **
FCS0389[-7]                           Chisq(1)=64.964     P=1.000 **
FCS0389[-8]                           Chisq(1)=55.834     P=1.000 **
FCS0389[-9]                           Chisq(1)=46.279     P=1.000 **
FCS0389[-10]                          Chisq(1)=45.999     P=1.000 **
FCS0389[-11]                          Chisq(1)=50.151     P=1.000 **
FCS0389[-12]                          Chisq(1)=41.620     P=1.000 **
FCS0389[-24]                          Chisq(1)=31.213     P=1.000 **

Try adding _AUTO[-1] to model.

Historical fit of dynamic regression model
Dependent variable: FCS0389
R-square: 0.902
Adjusted R-square: 0.902
Standard forecast error: 1325.836071
F statistic: 1431.116 (1.000)
Durbin-Watson: 2.176
Ljung-Box: 49.193 (1.000)
```

Standardized AIC: 1330.087710
Standardized BIC: 1347.920267 ** BEST

Variable	Coefficient	Standard error	T-stat	Prob
FCH0389	272.287933	15.727800	17.313	1.000
_CONST	12066.143483	591.419392	20.402	1.000
_AUTO[-1]	0.787552	0.028597	27.540	1.000

Model dynamics diagnostics

AUTO[-2] error term	Chisq(1)=5.993	P=0.986	*
AUTO[-3] error term	Chisq(1)=15.729	P=1.000	**
AUTO[-4] error term	Chisq(1)=13.282	P=1.000	**
AUTO[-5] error term	Chisq(1)=5.847	P=0.984	*
AUTO[-6] error term	Chisq(1)=11.657	P=0.999	**
AUTO[-7] error term	Chisq(1)=14.668	P=1.000	**
AUTO[-8] error term	Chisq(1)=4.251	P=0.961	*
AUTO[-9] error term	Chisq(1)=1.613	P=0.796	
AUTO[-10] error term	Chisq(1)=5.171	P=0.977	*
AUTO[-11] error term	Chisq(1)=13.476	P=1.000	**
AUTO[-12] error term	Chisq(1)=1.958	P=0.838	
AUTO[-24] error term	Chisq(1)=3.670	P=0.945	
FCS0389[-1]	Chisq(1)=1.497	P=0.779	
FCS0389[-2]	Chisq(1)=0.412	P=0.479	
FCS0389[-3]	Chisq(1)=1.067	P=0.698	
FCS0389[-4]	Chisq(1)=9.018	P=0.997	**
FCS0389[-5]	Chisq(1)=0.016	P=0.102	
FCS0389[-6]	Chisq(1)=0.776	P=0.622	
FCS0389[-7]	Chisq(1)=19.344	P=1.000	**
FCS0389[-8]	Chisq(1)=4.087	P=0.957	*
FCS0389[-9]	Chisq(1)=0.157	P=0.308	
FCS0389[-10]	Chisq(1)=0.436	P=0.491	
FCS0389[-11]	Chisq(1)=19.156	P=1.000	**
FCS0389[-12]	Chisq(1)=0.197	P=0.343	
FCS0389[-24]	Chisq(1)=5.064	P=0.976	*

Try adding FCS0389[-7] to model.

Historical fit of dynamic regression model
Dependent variable: FCS0389
R-square: 0.907
Adjusted R-square: 0.906
Standard forecast error: 1303.953646
F statistic: 1115.002 (1.000)
Durbin-Watson: 2.117
Ljung-Box: 33.542 (0.999)
Standardized AIC: 1309.610451
Standardized BIC: 1333.346012 ** BEST

Variable	Coefficient	Standard error	T-stat	Prob
FCH0389	264.054840	14.702335	17.960	1.000
_CONST	8885.152962	842.000116	10.552	1.000
FCS0389[-7]	0.166055	0.035438	4.686	1.000
_AUTO[-1]	0.750437	0.030886	24.297	1.000

Model dynamics diagnostics

AUTO[-2] error term	Chisq(1)=2.903	P=0.912	
AUTO[-3] error term	Chisq(1)=6.162	P=0.987	*
AUTO[-4] error term	Chisq(1)=4.726	P=0.970	*
AUTO[-5] error term	Chisq(1)=1.443	P=0.770	
AUTO[-6] error term	Chisq(1)=3.425	P=0.936	
AUTO[-7] error term	Chisq(1)=4.531	P=0.967	*
AUTO[-8] error term	Chisq(1)=5.828	P=0.984	*
AUTO[-9] error term	Chisq(1)=3.134	P=0.923	
AUTO[-10] error term	Chisq(1)=8.601	P=0.997	**
AUTO[-11] error term	Chisq(1)=18.892	P=1.000	**
AUTO[-12] error term	Chisq(1)=5.671	P=0.983	*
AUTO[-24] error term	Chisq(1)=13.650	P=1.000	**
FCS0389[-1]	Chisq(1)=0.879	P=0.652	
FCS0389[-2]	Chisq(1)=0.131	P=0.283	
FCS0389[-3]	Chisq(1)=0.073	P=0.212	
FCS0389[-4]	Chisq(1)=5.434	P=0.980	*
FCS0389[-5]	Chisq(1)=0.478	P=0.511	
FCS0389[-6]	Chisq(1)=2.882	P=0.910	
FCS0389[-8]	Chisq(1)=1.750	P=0.814	
FCS0389[-9]	Chisq(1)=1.540	P=0.785	

```
FCS0389[-10]                              Chisq(1)=1.027      P=0.689
FCS0389[-11]                              Chisq(1)=12.475     P=1.000 **
FCS0389[-12]                              Chisq(1)=1.746      P=0.814
FCS0389[-24]                              Chisq(1)=14.237     P=1.000 **

Try adding _AUTO[-11] to model.

Model dynamics diagnostics
AUTO[-2] error term                       Chisq(1)=2.903      P=0.912
AUTO[-3] error term                       Chisq(1)=6.162      P=0.987 *
AUTO[-4] error term                       Chisq(1)=4.726      P=0.970 *
AUTO[-5] error term                       Chisq(1)=1.443      P=0.770
AUTO[-6] error term                       Chisq(1)=3.425      P=0.936
AUTO[-7] error term                       Chisq(1)=4.531      P=0.967 *
AUTO[-8] error term                       Chisq(1)=5.828      P=0.984 *
AUTO[-9] error term                       Chisq(1)=3.134      P=0.923
AUTO[-10] error term                      Chisq(1)=8.601      P=0.997 **
AUTO[-11] error term                      Chisq(1)=18.892     P=1.000 **
AUTO[-12] error term                      Chisq(1)=5.671      P=0.983 *
AUTO[-24] error term                      Chisq(1)=13.650     P=1.000 **
FCS0389[-1]                               Chisq(1)=0.879      P=0.652
FCS0389[-2]                               Chisq(1)=0.131      P=0.283
FCS0389[-3]                               Chisq(1)=0.073      P=0.212
FCS0389[-4]                               Chisq(1)=5.434      P=0.980 *
FCS0389[-5]                               Chisq(1)=0.478      P=0.511
FCS0389[-6]                               Chisq(1)=2.882      P=0.910
FCS0389[-8]                               Chisq(1)=1.750      P=0.814
FCS0389[-9]                               Chisq(1)=1.540      P=0.785
FCS0389[-10]                              Chisq(1)=1.027      P=0.689
FCS0389[-11]                              Chisq(1)=12.475     P=1.000 **
FCS0389[-12]                              Chisq(1)=1.746      P=0.814
FCS0389[-24]                              Chisq(1)=14.237     P=1.000 **

Try adding _AUTO[-11] to model.

Historical fit of dynamic regression model
Dependent variable: FCS0389
R-square: 0.916
Adjusted R-square: 0.915
Standard forecast error: 1245.347190
F statistic: 970.561 (1.000)
Durbin-Watson: 2.119
Ljung-Box: 15.033 (0.760)
Standardized AIC: 1252.246100
Standardized BIC: 1281.162633 ** BEST

Variable        Coefficient    Standard error     T-stat        Prob
FCH0389          277.782346       13.452923       20.648       1.000
_CONST          8832.197930      830.127799       10.640       1.000
FCS0389[-7]        0.134648        0.033271        4.047       1.000
_AUTO[-1]          0.677659        0.032754       20.689       1.000
_AUTO[-11]         0.144157        0.032090        4.492       1.000

Model dynamics diagnostics
AUTO[-2] error term                       Chisq(1)=3.319      P=0.932
AUTO[-3] error term                       Chisq(1)=6.972      P=0.992 **
AUTO[-4] error term                       Chisq(1)=5.360      P=0.979 *
AUTO[-5] error term                       Chisq(1)=1.109      P=0.708
AUTO[-6] error term                       Chisq(1)=2.665      P=0.897
AUTO[-7] error term                       Chisq(1)=2.788      P=0.905
AUTO[-8] error term                       Chisq(1)=2.150      P=0.857
AUTO[-9] error term                       Chisq(1)=0.011      P=0.082
AUTO[-10] error term                      Chisq(1)=0.000      P=0.015
AUTO[-12] error term                      Chisq(1)=2.962      P=0.915
AUTO[-24] error term                      Chisq(1)=6.889      P=0.991 **
FCS0389[-1]                               Chisq(1)=0.389      P=0.467
FCS0389[-2]                               Chisq(1)=0.622      P=0.570
FCS0389[-3]                               Chisq(1)=1.519      P=0.782
FCS0389[-4]                               Chisq(1)=4.762      P=0.971 *
FCS0389[-5]                               Chisq(1)=2.918      P=0.912
FCS0389[-6]                               Chisq(1)=7.117      P=0.992 **
FCS0389[-8]                               Chisq(1)=2.510      P=0.887
FCS0389[-9]                               Chisq(1)=5.681      P=0.983 *
FCS0389[-10]                              Chisq(1)=3.932      P=0.953 *
FCS0389[-11]                              Chisq(1)=4.767      P=0.971 *
```

FCS0389[-12]	Chisq(1)=8.253	P=0.996 **
FCS0389[-24]	Chisq(1)=6.371	P=0.988 *

Try adding FCS0389[-12] to model.

Historical fit of dynamic regression model
Dependent variable: FCS0389
R-square: 0.917
Adjusted R-square: 0.916
Standard forecast error: 1233.196320
F statistic: 810.440 (1.000)
Durbin-Watson: 2.060
Ljung-Box: 10.582 (0.435)
Standardized AIC: 1241.481152
Standardized BIC: 1276.258322 ** BEST

Variable	Coefficient	Standard error	T-stat	Prob	
FCH0389	280.899719	12.537409	22.405	1.000	
_CONST	9777.794400	969.716349	10.083	1.000	
FCS0389[-7]	0.125041	0.032521	3.845	1.000	
FCS0389[-12]	-0.047088	0.033514	-1.405	0.840	<-
_AUTO[-1]	0.632723	0.034726	18.220	1.000	
_AUTO[-11]	0.184922	0.034005	5.438	1.000	

Eliminate marked nonsignificant variable.

Model dynamics diagnostics

AUTO[-2] error term	Chisq(1)=1.326	P=0.751
AUTO[-3] error term	Chisq(1)=3.902	P=0.952 *
AUTO[-4] error term	Chisq(1)=2.592	P=0.893
AUTO[-5] error term	Chisq(1)=0.105	P=0.254
AUTO[-6] error term	Chisq(1)=0.855	P=0.645
AUTO[-7] error term	Chisq(1)=0.884	P=0.653
AUTO[-8] error term	Chisq(1)=0.829	P=0.637
AUTO[-9] error term	Chisq(1)=0.170	P=0.320
AUTO[-10] error term	Chisq(1)=0.042	P=0.162
AUTO[-12] error term	Chisq(1)=0.327	P=0.433
AUTO[-24] error term	Chisq(1)=1.887	P=0.830
FCS0389[-1]	Chisq(1)=0.012	P=0.087
FCS0389[-2]	Chisq(1)=0.060	P=0.194
FCS0389[-3]	Chisq(1)=0.090	P=0.236
FCS0389[-4]	Chisq(1)=3.079	P=0.921
FCS0389[-5]	Chisq(1)=1.145	P=0.715
FCS0389[-6]	Chisq(1)=5.996	P=0.986 *
FCS0389[-8]	Chisq(1)=2.940	P=0.914
FCS0389[-9]	Chisq(1)=5.687	P=0.983 *
FCS0389[-10]	Chisq(1)=4.213	P=0.960 *
FCS0389[-11]	Chisq(1)=3.402	P=0.935
FCS0389[-24]	Chisq(1)=1.937	P=0.836

Dynamics look OK. Go on to explanatory variables.

Historical fit of dynamic regression model
Dependent variable: FCS0389
R-square: 0.918
Adjusted R-square: 0.917
Standard forecast error: 1229.141131
F statistic: 699.812 (1.000)
Durbin-Watson: 2.000
Ljung-Box: 8.221 (0.232)
Standardized AIC: 1238.769204
Standardized BIC: 1273.347720

Variable	Coefficient	Standard error	T-stat	Prob	
FCH0389	282.819966	12.794953	22.104	1.000	
_CONST	9839.235118	1025.047317	9.599	1.000	
FCS0389[-7]	0.112448	0.033198	3.387	0.999	
FCS0389[-12]	-0.043170	0.034329	-1.258	0.791	<-
_AUTO[-1]	0.592417	0.040200	14.737	1.000	
_AUTO[-11]	0.171968	0.034943	4.921	1.000	
_AUTO[-3]	0.079267	0.040754	1.945	0.948	

Eliminate marked nonsignificant variable.

Historical fit of dynamic regression model

Dependent variable: FCS0389
R-square: 0.917
Adjusted R-square: 0.916
Standard forecast error: 1236.836187
F statistic: 821.162 (1.000)
Durbin-Watson: 2.034
Ljung-Box: 11.461 (0.510)
Standardized AIC: 1245.053474
Standardized BIC: 1279.633187

Variable	Coefficient	Standard error	T-stat	Prob
FCH0389	282.042111	13.639318	20.679	1.000
_CONST	8998.438308	897.810555	10.023	1.000
FCS0389[-7]	0.116499	0.034008	3.426	0.999
_AUTO[-1]	0.617025	0.039490	15.625	1.000
_AUTO[-11]	0.132400	0.032216	4.110	1.000
_AUTO[-3]	0.106643	0.039926	2.671	0.992

Model dynamics diagnostics

AUTO[-2] error term	Chisq(1)=0.195	P=0.342	
AUTO[-4] error term	Chisq(1)=0.838	P=0.640	
AUTO[-5] error term	Chisq(1)=0.001	P=0.023	
AUTO[-6] error term	Chisq(1)=0.718	P=0.603	
AUTO[-7] error term	Chisq(1)=1.134	P=0.713	
AUTO[-8] error term	Chisq(1)=0.912	P=0.660	
AUTO[-9] error term	Chisq(1)=0.243	P=0.378	
AUTO[-10] error term	Chisq(1)=0.090	P=0.236	
AUTO[-12] error term	Chisq(1)=2.498	P=0.886	
AUTO[-24] error term	Chisq(1)=6.278	P=0.988	*
FCS0389[-1]	Chisq(1)=0.426	P=0.486	
FCS0389[-2]	Chisq(1)=1.047	P=0.694	
FCS0389[-3]	Chisq(1)=2.316	P=0.872	
FCS0389[-4]	Chisq(1)=2.573	P=0.891	
FCS0389[-5]	Chisq(1)=3.659	P=0.944	
FCS0389[-6]	Chisq(1)=7.347	P=0.993	**
FCS0389[-8]	Chisq(1)=2.288	P=0.870	
FCS0389[-9]	Chisq(1)=4.537	P=0.967	*
FCS0389[-10]	Chisq(1)=3.567	P=0.941	
FCS0389[-11]	Chisq(1)=4.358	P=0.963	*
FCS0389[-12]	Chisq(1)=7.792	P=0.995	**
FCS0389[-24]	Chisq(1)=4.199	P=0.960	*

Try adding FCS0389[-12] to model.

Historical fit of dynamic regression model
Dependent variable: FCS0389
R-square: 0.918
Adjusted R-square: 0.917
Standard forecast error: 1229.141131
F statistic: 699.812 (1.000)
Durbin-Watson: 2.000
Ljung-Box: 8.221 (0.232)
Standardized AIC: 1238.769204
Standardized BIC: 1279.347720

Variable	Coefficient	Standard error	T-stat	Prob	
FCH0389	282.819966	12.794953	22.104	1.000	
_CONST	9839.235118	1025.047317	9.599	1.000	
FCS0389[-7]	0.112448	0.033198	3.387	0.999	
FCS0389[-12]	-0.043170	0.034329	-1.258	0.791	<-
_AUTO[-1]	0.592417	0.040200	14.737	1.000	
_AUTO[-11]	0.171968	0.034943	4.921	1.000	
_AUTO[-3]	0.079267	0.040754	1.945	0.948	

Eliminate marked nonsignificant variable.

Model dynamics diagnostics

AUTO[-2] error term	Chisq(1)=0.016	P=0.101
AUTO[-4] error term	Chisq(1)=0.312	P=0.424
AUTO[-5] error term	Chisq(1)=0.241	P=0.377
AUTO[-6] error term	Chisq(1)=0.121	P=0.272
AUTO[-7] error term	Chisq(1)=0.264	P=0.393
AUTO[-8] error term	Chisq(1)=0.338	P=0.439
AUTO[-9] error term	Chisq(1)=0.410	P=0.478
AUTO[-10] error term	Chisq(1)=0.157	P=0.308

```
AUTO[-12] error term                            Chisq(1)=0.366          P=0.455
AUTO[-24] error term                            Chisq(1)=1.904          P=0.832
FCS0389[-1]                                     Chisq(1)=0.401          P=0.473
FCS0389[-2]                                     Chisq(1)=0.387          P=0.466
FCS0389[-3]                                     Chisq(1)=0.792          P=0.627
FCS0389[-4]                                     Chisq(1)=1.361          P=0.757
FCS0389[-5]                                     Chisq(1)=1.782          P=0.818
FCS0389[-6]                                     Chisq(1)=6.316          P=0.988 *
FCS0389[-8]                                     Chisq(1)=2.685          P=0.899
FCS0389[-9]                                     Chisq(1)=4.761          P=0.971 *
FCS0389[-10]                                    Chisq(1)=3.639          P=0.944
FCS0389[-11]                                    Chisq(1)=2.845          P=0.908
FCS0389[-24]                                    Chisq(1)=1.608          P=0.795

Dynamics look OK.  Go on to explanatory variables.

Historical fit of dynamic regression model
Dependent variable: FCS0389
R-square: 0.919
Adjusted R-square: 0.917
Standard forecast error: 1223.959042
F statistic: 618.121 (1.000)
Durbin-Watson: 2.023
Ljung-Box: 11.661 (0.527)
Standardized AIC: 1234.909522
Standardized BIC: 1281.247648

Variable           Coefficient     Standard error      T-stat          Prob
FCH0389             288.752472         13.156314       21.948         1.000
_CONST            10447.648383       1073.790874        9.730         1.000
FCS0389[-7]           0.143698          0.035932        3.999         1.000
FCS0389[-12]         -0.033800          0.034549       -0.978         0.672 <-
FCS0389[-6]          -0.079893          0.036977       -2.161         0.969
_AUTO[-1]             0.595823          0.040156       14.838         1.000
_AUTO[-11]            0.166958          0.035003        4.770         1.000
_AUTO[-3]             0.085885          0.041121        2.089         0.963

Eliminate marked nonsignificant variable.

Model dynamics diagnostics
AUTO[-2] error term                             Chisq(1)=0.223          P=0.363
AUTO[-4] error term                             Chisq(1)=0.915          P=0.661
AUTO[-5] error term                             Chisq(1)=0.058          P=0.190
AUTO[-6] error term                             Chisq(1)=2.760          P=0.903
AUTO[-7] error term                             Chisq(1)=0.006          P=0.063
AUTO[-8] error term                             Chisq(1)=0.429          P=0.488
AUTO[-9] error term                             Chisq(1)=0.252          P=0.384
AUTO[-10] error term                            Chisq(1)=0.057          P=0.188
AUTO[-12] error term                            Chisq(1)=0.244          P=0.379
AUTO[-24] error term                            Chisq(1)=1.948          P=0.837
FCS0389[-1]                                     Chisq(1)=0.227          P=0.366
FCS0389[-2]                                     Chisq(1)=1.185          P=0.724
FCS0389[-3]                                     Chisq(1)=0.455          P=0.500
FCS0389[-4]                                     Chisq(1)=2.716          P=0.901
FCS0389[-5]                                     Chisq(1)=0.803          P=0.630
FCS0389[-8]                                     Chisq(1)=3.377          P=0.934
FCS0389[-9]                                     Chisq(1)=3.935          P=0.953 *
FCS0389[-10]                                    Chisq(1)=3.460          P=0.937
FCS0389[-11]                                    Chisq(1)=3.040          P=0.919
FCS0389[-24]                                    Chisq(1)=1.624          P=0.797

Dynamics look OK.  Go on to explanatory variables.

Variable specification diagnostics
TIME TREND                                      Chisq(1)=3.439          P=0.936
NONLINEARITY in predictors                      Chisq(5)=14.038         P=0.985 *

Specification looks OK.  Go on to final checks.

Model homogeneity diagnostics
HETEROSCEDASTICITY with time                    Chisq(1)=0.229          P=0.368
HETEROSCEDASTICITY with predictors              Chisq(5)=5.438          P=0.635
HETEROSCEDASTICITY with fitted values           Chisq(1)=3.718          P=0.946
CHOW test for changing parameters               F(5,432)=5.52           P=1.000 **
```

Model appears to be homogeneous (stable over time).

FORECAST PRO forecasts Fri Nov 30 15:45:56 1990

Dynamic regression model parameters

Dynamic regression forecasts
Parameter values

Variable	Coefficient
FCH0389	288.752472
_CONST	10447.648383
FCS0389[-7]	0.143698
FCS0389[-12]	-0.033800
FCS0389[-6]	-0.079893
_AUTO[-1]	
_AUTO[-11]	
_AUTO[-3]	

Forecast variable &FORECST

Period	Forecast	Lower (95%)	Upper (95%)
1-1939	17424.236328	14861.741032	19986.731625
2-1939	19296.718750	16313.853747	22279.583753
3-1939	19026.162109	15907.662893	22144.661326
4-1939	20508.833984	17298.563719	23719.104249
5-1939	21295.003906	18031.830300	24558.177512
6-1939	19272.560547	15981.592849	22563.528245
7-1939	22250.460938	18957.483465	25543.438410
8-1939	21133.373047	17804.575258	24462.170836
9-1939	16963.941406	13619.136813	20308.746000
10-1939	15289.373047	11938.315607	18640.430487
11-1939	15007.059570	11652.003971	18362.115169
12-1939	14237.042969	10836.643250	17637.442688
1-1940	13522.892578	10081.129062	16964.656094
2-1940	13457.079102	9989.287051	16924.871152
3-1940	13433.606445	9932.702007	16934.510883
4-1940	12976.503906	9449.338649	16503.669163
5-1940	12869.222656	9323.360628	16415.084685
6-1940	13435.632813	9878.957289	16992.308336
7-1940	14104.988281	10536.028067	17673.948495
8-1940	14619.756836	11042.448953	18197.064719
9-1940	15126.981445	11544.588494	18709.374397
10-1940	15530.203125	11943.585051	19116.821199
11-1940	16123.522461	12530.341077	19716.703845
12-1940	16526.171875	12925.343409	20127.000341

Expert data exploration of dependent variable FCS0389

BASIC STATISTICS
Number of observations: 468
Standard deviation: 4227.444463
Minimum: 12380.490234 Maximum: 33036.289063
Trend-cycle 85.15% Seasonal 1.14% Irregular 13.72%

BASIC PROPERTIES
A power transformation may help - try the logarithm.
Correlational structure is strong.
Series is stationary.
There are no active explanatory variables.
Data appear to be homogeneous.
Series is seasonal.

RECOMMENDED METHOD: BOX-JENKINS.

Historical fit of Box-Jenkins model
Dependent variable: FCS0389
R-square: 0.859
Adjusted R-square: 0.858
Standard forecast error: 1591.180824
F statistic: 1418.705 (1.000)
Durbin-Watson: 2.122
Ljung-Box: 40.319 (1.000)
Standardized AIC: 1594.577117
Standardized BIC: 1608.774677

BJ Parameter	Coefficient	Standard error	T-stat	Prob
A[1]	0.948963	0.053392	17.774	1.000
A[12]	-0.057107	0.047785	-1.195	0.768
CONSTANT	1133.506717			

Try alternative model ARIMA(1,0,0)*ARIMA12(0,0,0)

FORECAST PRO forecasts Fri Nov 30 15:49:02 1990

Box-Jenkins model parameters

A[1]	0.948963
A[12]	-0.057107
CONSTANT	1133.506717

Forecast variable &FBJECST

Period	Forecast	Lower (95%)	Upper (95%)
1-1939	18320.146484	15102.597130	21537.695839
2-1939	18517.460938	14081.755359	22953.166516
3-1939	18731.474609	13433.266438	24029.682781
4-1939	18820.138672	12850.930829	24789.346515
5-1939	19062.517578	12547.930323	25577.104834
6-1939	19128.017578	12158.725816	26097.309340
7-1939	19046.685547	11691.935608	26401.435486
8-1939	19204.281250	11518.940246	26889.622254
9-1939	19201.476563	11230.152021	27172.801104
10-1939	19558.382813	11338.030819	27778.734806
11-1939	19622.320313	11183.998011	28060.642614
12-1939	19564.583984	10934.682558	28194.485411
1-1940	19646.425781	10881.552443	28411.299119
2-1940	19712.578125	10827.912850	28597.243400
3-1940	19773.826172	10782.650210	28765.002134
4-1940	19838.482422	10752.458661	28924.506183
5-1940	19890.802734	10720.205001	29061.400468
6-1940	19949.845703	10703.748450	29195.942956
7-1940	20014.070313	10700.507118	29327.633507
8-1940	20061.609375	10687.706510	29435.512240
9-1940	20115.423828	10687.513678	29543.333979
10-1940	20145.957031	10669.675031	29622.239031
11-1940	20190.623047	10670.991021	29710.255072
12-1940	20239.771484	10681.269651	29798.273318

ABBREVIATIONS AND ACRONYMS

ACF	autocorrelation function
AIC	Akaike Information Criterion
ARMA	autoregressive-moving average
ARIMA	autoregressive integrated moving average
BIC	Bayesian Information Criterion
EPRI	Electric Power Research Institute
IEEE	Institute of Electrical and Electronics Engineers
ORSA	Operations Research Society of America
PACF	partial autocorrelation function
PICA	Power Industry Computer Applications (Conference)
SAS/ETS	SAS Econometric and Time-Series Library
TIMS	The Institute of Management Sciences
UIUC	University of Illinois at Urbana-Champaign
USACERL	U.S. Army Construction Engineering Research Laboratory

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